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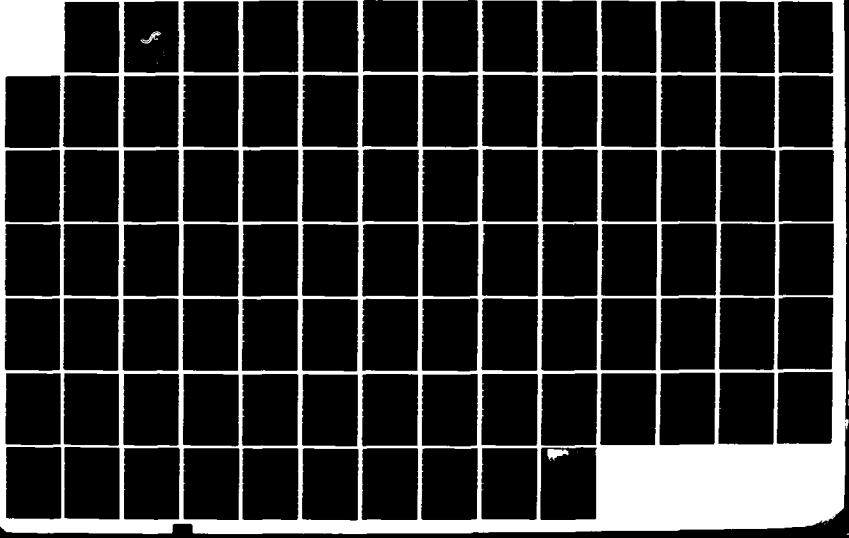

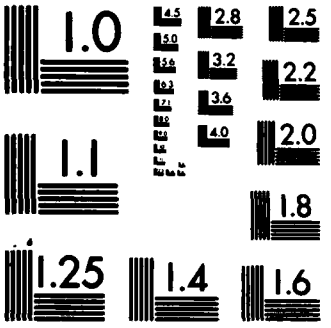

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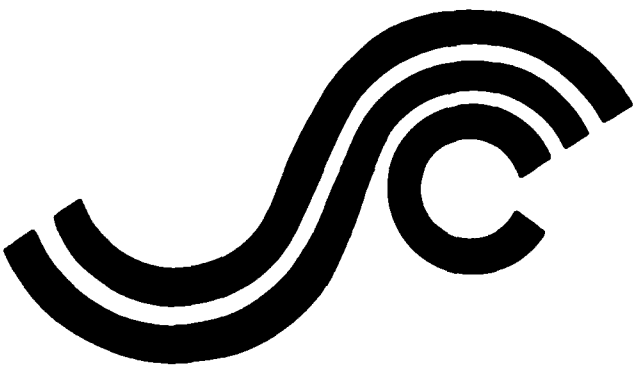

SHIP STRUCTURE COMMITTEE

SHIP STRUCTURE COMMITTEE

The SHIP STRUCTURE COMMITTEE is constituted to prosecute a research program to improve the hull structures of ships and other marine structures by an extension of knowledge pertaining to design, materials and methods of construction.

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The SHIP STRUCTURE SUBCOMMITTEE acts for the Ship Structure Committee on technical matters by providing technical coordination for the determination of goals and objectives of the program, and by evaluating and interpreting the results in terms of structural design, construction and operation.

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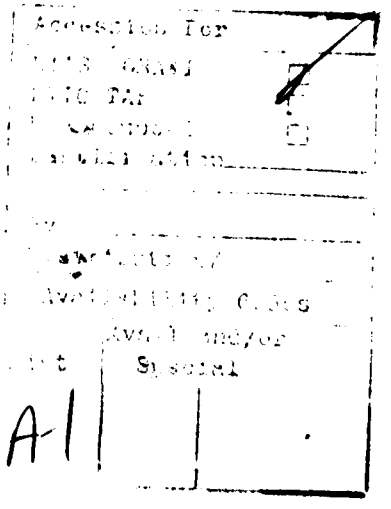
SHIP STRUCTURE COMMITTEE PUBLICATIONS

This bibliography contains all publications of the Ship Structure Committee from its inception in 1946 to mid 1981 and was complied from the computer files of the Maritime Research Information Service (MRIS), which is available via the Lockheed DIALOG System. The Ship Structure Committee Reports have been announced in the National Technical Information Service (NTIS) publications, U. S. Government Research & Development Reports (USGRDR) under the indicated AD numbers in the last section of the bibliography. They are distributed by NTIS in Springfield, VA 22151.

It contains four distinct sections. The first section provides report abstracts in numberical order according to the MRIS number. The second section is an alphabetical listing of authors showing their MRIS report numbers. The third section is a subject term index with key words listed alphabetically showing the MRIS report numbers using the keyword shown. The final section lists the Ship Structure Committee reports in numerical order and shows the corresponsding MRIS and NTIS numbers.

Washington, D.C.
U.S. Coast Guard Headquarters

July 1981



Abstracts of Reports

001924

FEASIBILITY STUDY OF MODEL TESTS ON SHIP HULL GIRDERS

A program is identified for strength testing of hull girder models representative of longitudinally framed ship construction. The purpose of the tests is to generate data (for correlation with theory where available) to provide the basis for engineering design of the primary structure of the hull girder. The major loads are longitudinal compression induced by primary hull bending, normal pressure from the seam and athwartship compression induced by the horizontal pressure on the sidewalls. (Author)

Becker, HD
Mithras, (SF-013-03-04) Final Prt. SSC-194, M-7006 R1(BTX), May 1969, 63Pp

ORDER FROM: NTIS

AD-687220

002108

ANALYSIS AND INTERPRETATION OF FULL-SCALE DATA ON MIDSHIP BENDING STRESSES OF DRY CARGO SHIPS

Results of the analysis of stress data from full-scale measurements on two C-4 type cargo vessels are presented in the form of histograms and cumulative distributions, which together with previously analyzed full-scale data cover a total of five years of normal ship operation in the North Atlantic. Two rational techniques are given for the extrapolation of full-scale data to longer periods of time, in order to predict extreme bending stresses (or bending moments) in service. Recommendations are made for more data collection from different ships on different routes, for investigation of other statistical techniques, and for development of methods for model predictions of long-term trends. (Author)

Hoffman, D Lewis, EV
Webb Institute of Naval Architecture, (SF-013-04) Tech Rpt. SSC-196, June 1969, 67Pp

NOBS-92384

ORDER FROM: NTIS

AD-689657

002112

METALLURGICAL STRUCTURE AND THE BRITTLE BEHAVIOR OF STEEL

By means of surface-replication and three-dimensional metallography, it has become possible to delineate the interrelated processes of slip, twinning, carbide cracking, void formation and microcleavage in the tensile testing of iron and mild steels at subatmospheric temperatures. The cracking of intergranular carbides is an especially potent means of microcleavage initiation, and can be used as a tell-tale to follow the fracturing sequences. There are indications that the amount and size of intergranular carbides in mild steels are reduced by decreased carbon content, increased manganese content, increased cooling rate from the austenitizing temperature, and decreased grain size. The initiation of microcleavage via carbide cracking can be treated statistically, on the assumption that the number of carbide cracks per unit volume is proportional to the plastic strain, and that the size distribution of carbide strain is parabolic up to the maximum size present. (Author)

Cohen, M
Massachusetts Institute of Technology, (SR-136) Final Rpt. SSC-183, May 1968, 32Pp

NOBS-88279

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AD-670574

002148

FLAME STRAIGHTENING AND ITS EFFECT ON BASE METAL PROPERTIES

The suitability of flame-strainghtening methods now used on conventional ship steels for the higher strength ship steels is questionable. The report discusses some of the potential problem areas that need evaluation to examine this subject. Based on a survey of pertinent literature it is shown that only limited data applicable to this subject are available. The data analysis covered the nature of distortion, flame-straightening techniques, and the effects of both single and combined thermal cycles and plastic strain cycles on material properties. An experimental program is presented that is designed to generate background data on conventional steels and several higher strength steels directly pertinent to flame straightening. These data will subsequently be evaluated to ascertain suitability of the flame-straightening procedure for various ship steels. (Author)

REFERENCES:

Pattee, HE Evans, RM Monroe, RE
Battelle Memorial Institute, (SR-185) Summ Rpt. SSC-198, Aug. 1969, 41Pp

ORDER FROM: NTIS

AD-691555

002206

STUDY OF THE FACTORS WHICH AFFECT THE ADEQUACY OF HIGH-STRENGTH LOW-ALLOY STEEL WELDMENTS FOR CARGO SHIP HULLS

A recent advent in ship construction is the use of high-strength low-alloy steels with 100,000-Psi yield strengths for ship hull structural elements, making unique design concepts possible. This application is a significant step, but the materials behavior needs to be further defined. For the benefit of the owners, designers, and fabricators, a project was initiated by the ship structure committee to establish which mechanical properties should be used as criteria for judging performance, to evaluate large-scale weldments to determine the suitability of these criteria, and to select small-scale laboratory tests that correlate with the large-scale tests. A survey of shipyards and ship repairers revealed that these newer materials are being used only in critical strength elements ships hulls. Welding procedures are qualified by explosion bulge tests to define safe operating temperature limits. (Author)

Lowenberg, AL Norris, EB Pickett, AG Wylie, RD
Southwest Research Institute, (SR-177) Tech Rpt. SSC-199, Aug. 1969, 59Pp

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AD-692262

007502

A CRITICAL SURVEY OF BRITTLE FRACTURE IN CARBON PLATE STEEL STRUCTURES, OTHER THAN SHIPS

The failure of ships at sea and at dockside during World War II brought the problem of brittle fracture into sharp focus. Data from ship failures have been well correlated, and as a result, much has been learned from research stimulated thereby. No similar correlation on nonship failure data exists, and this survey was therefore undertaken in order to supplement the study of ship failures. A total of 64 structural failures, plus failures in gas transmission lines, was studied. These failures occurred in both riveted and welded structures such as tanks, bridges, pressure vessels, a smoke stack, a penstock, power shovels, as well as gas transmission lines. It is shown that the history of brittle failure extends back at least to 1879. It is con- cluded that: (1) Brittle failure in nonstop structures is the same phenomenon as occurs in ships; (2) brittle failure occurs in many types of nonship structures; (3) brittle fractures can cross riveted joints; (4) there is no evidence to show that the percentage incidence of brittle failure has either decreased or increased with the advent of weld- ing; (5) in conjunction with other factors, thermal stress may be important; (6) residual stresses are not the prime cause of brittle failure, but such stresses may, in con- junction with other factors, initiate such failure; (7) the effect of metallurgical variables is important; (8) cold forming promotes susceptibility to brittle failure, but its role cannot be assessed due to lack of data; (9) in such cases where data are available,

Charpy impact values of plate were generally low at the failure temperature; (10) in most cases of nonship brittle failure, the fracture originated at defects arising from fabrication. A few originated at design defects; (11) it seems evident in all cases that fracture originated at a geometric discontinuity; (12) no evidence exists for these failed structures to show the effects of various welding processes on susceptibility to brittle failure; (13) except in the case of exceptionally poor welds, there is no tendency for fracture to follow welded seams; (14) the great majority of nonship brittle failures apparently occur under conditions of entirely static loading; (15) age of structure seems to have no bearing on brittle failure; (16) most engineering codes permit the use of steel which is known to be particularly susceptible to brittle failure. At the same time, under all codes but one, the stress levels are held to quite conservative values; (17) finally, it is demonstrated that brittle failure results from a combination of many factors. There is no readily available material which would entirely prevent its occurrence, and there is no known test which will surely preduct from the behavior of small specimens the performance of a given steel in circumstances where structural brittle failure might occur. In short, careful design, selection of materials, and good workmanship are of the greatest importance in the prevention of brittle failure in nonship structures. This is true of ships.

Prepared for National Research Councils Committee on Ship Structural Design

Shank, ME (Massachusetts Institute of Technology)
Ship Structure Committee, Bureau of Ships SSC- 65, Dec. 1953, 49pp, 12 Fig, 2 Tab, 33 Pho

NObs-50148

ORDER FROM: NTIS

AD 73877

007503

THE INVESTIGATION OF RADIOISOTOPES FOR THE INSPECTION OF SHIP WELDS

A study was conducted that explored the potentialities of radioactive isotopes for the inspection of welds in ship structures. Various parameters were investigated to determine an optimum radiographic technique for the in- spection of hull welds of 1/2-to 2-in. plate. Technique and sensitivity curves for thulium, iridium, cesium, and cobalt are included. For the inspection of welds in 1/2-in. to 1-in. thick plate, iridium is the most promising isotope. A portable exposure container for iridium has been developed.

Criscuolo, EL Case, DP Polansky, D (Naval Ordnance Laboratory)
Ship Structure Committee, Bureau of Ships, (SR-127) Prog Rpt SSC-110, Feb. 1958, 57pp, 35 Fig, 4 Tab, 2 Pho, 12 Ref, 1 App

92703

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007504

MANUAL OF ISOTOPE RADIOGRAPHY

The purpose of this manual is to present information and experimental data on the radiography of steel (particular- ly welds) using isotopes. This information will assist the radiographer in selecting the proper technique. The technique described can be applied to the radiographic inspection of welds contained in ship structures. No attempt is made in this document to evaluate the discon- tinuities other than to familiarize the reader with the interpretation and classification of defects.

Criscuolo, EL Polansky, D Dyer, Charles H (Naval Ordnance Laboratory)
Ship Structure Committee, Bureau of Ships, (SR-127) Final Rpt SSC-121, May 1960, 48pp, 27 Fig, 6 Tab, 11 Ref

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007505

LOW-CYCLE FATIGUE OF METALS-LITERATURE REVIEW

An evaluation of the data on low-cycle fatigue of metals based on type of test, cyclic rate, stress concentration, crack propagation, material property change and method of analysis indicates that (a) there is presently no general analysis applicable to all low-cycle fatigue test con- ditions; (b) the shape of the load-time curve is an important factor in analyzing low-cycle fatigue tests; (c) the extent of the time effect on low-cycle fatigue behavior, particularly with respect to creep and crack propagation, still remains to be explored; (d) the use of strain rather than stress is more desirable in low-cycle fatigue studies of coupon-type specimens because of the plastic deformation that takes place during such tests; and (e) the fatigue hypotheses based on strain, although developed from limited data, exhibit good agreement with the test results and show promise of providing a good in- dication of low-cycle fatigue behavior for selected loading conditions.

Transmitted through Committee on Ship Structural Design, National Academy of Sciences. Bushps No. NS-731-036

REFERENCES:

Yao, JTP Munse, WH (Illinois University)
Ship Structure Committee, Bureau of Ships, (SR-149) Prog Rpt SSC-137, Oct. 1961, 30pp, 7 Fig, 69 Ref, 1 App

Contract NObs-72046

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007506

SUMMARY OF INVESTIGATION OF MIDSHIP BENDING MOMENTS EXPERIENCED BY MODELS IN EXTREME REGULAR WAVES

This report summarizes experimental research to investigate the possibility of a physical upper limit on midship bending moments being reached in regular waves of height sig- nificantly less than the theoretical upper limit of progressive waves (h/lambda equals 1/7). The experiments included variation of ship type, of dis- tribution of loading and of freeboard as model parameters. The ship types investigated were a modern cargo vessel, a large tanker, and a modern destroyer. Each model was tested at various speeds in regular head and following waves of several different lengths and of a wide range of heights. No significant upper limit of bending moment was found. However, the study establishes more firmly the grossly linear dependence of midship bending moment on wave height, even for extreme wave heights which may be encountered in service. These findings strengthened the case for deter- mining design wave bending moments on the basis of statistical analyses of ocean waves and/or resulting bending moments.

Project name is Model in Extreme Waves

Dalzell, JF (Stevens Institute of Technology)
Ship Structure Committee, Bureau of Ships, (SR-157) Final Rpt. SSC-157, Dec. 1963, 16pp, 19 Fig, 7 Tab, 1 Pho, 3 Ref

NObs-88509

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007507

INVESTIGATION OF BENDING MOMENTS WITHIN THE MIDSHIP HALF LENGTH OF A MARINER MODEL IN EXTREME WAVES

One objective of this report was to obtain experimental model data to describe the lengthwise vertical wave bending moment distribution within the midship half length of a normally loaded Mariner type cargo ship in regular head and following waves having wave height/wave length ratios between 0.05 and 0.11; a second loading condition was also examined. A second objective was to determine whether the moments tend to reach an upper limit as wave height increases. A 1/96 scale model was cut to form six segments which were jointed by an aluminum beam. The beam was strain gaged to measure bending moments at the hull cuts at stations 5, 7-1/2, 10, 12-1/2 and 15. Within practical operational limits for the Mariner type ship, maximum wave bending moments in high regular waves occur in the region from amidships to .125L aft of amidships. Hogging and sagging moment at any section were generally proportional to wave height up to a wave height/wave length ratio of 0.11, the steepest wave that could be generated.

Maniar, NM
Ship Structure Committee, Bureau of Ships, (SR-165) Prog Rpt SSC-163, June 1964, 22pp, 61 Fig, 3 Tab, 2 Pho, 3 Ref

NObs-88263

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007508

GUIDE FOR INTERPRETATION OF NON-DESTRUCTIVE TESTS OF WELDS IN SHIP HULL STRUCTURES

A survey was made of various Codes and Standards applicable to the interpretation of radiographs of welds and the Guide has been developed for application to welds in ship hull structures of the general cargo, tanker and passenger class as differentiated from naval ships. The Guide exhibits typical X-ray and other non-destructive test results of several classes of defects with suitable text to delineate the maximum size and/or distribution that would be recommended as acceptable for ship hulls.

Prepared by the Weld Flaw Evaluation Committee, NAS/NRC.

Ship Structure Committee, Bureau of Ships SSC-177, Sept. 1966, 15pp, 3 Fig, 19 Pho

NObs-90310

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007509

EXHAUSTION OF DUCTILITY IN COMPRESSED BARS WITH HOLES

The brittleness of mild steel subjected to tension after prior compressive prestraining has been in part attributed to the collapse of microscopic flaws or voids and to the resulting severe straining, work hardening, and sharpening of the flaw edges. A similar mechanism of embrittlement should operate also with artificial macroscopic flaws as holes. This was checked with tests of axially com- pressed bars of ABS-B and of E-steel with transverse pre- or post-drilled single or double holes. The overall nominal compressive prestrain (exhaustion limit) causing brittleness in subsequent tension in bars with pre-drilled holes was about 1/4 the corresponding prestrain for solid bars of E-steel and about 1/2 for ABS-B steel. The possible causes of this difference and the modes of fracture initiation and propagation are discussed. The strong differentiation of steel quality achieved with these tests is very promising for the development of a related acceptance test.

Project name is Macrofracture Fundamentals

Kobayashi, S Mylonas, C (Brown University)
Ship Structure Committee, Naval Ship Engineering Center, (SR-158) Prog Rpt SSC-184, June 1968, 22pp, 3 Fig, 4 Tab, 6 Pho, 21 Ref

NObs 88294

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007512

EFFECT OF REPEATED LOADS ON THE LOW TEMPERATURE FRACTURE BEHAVIOR OF NOTCHED AND WELDED PLATES

The influence of repeated loadings on the susceptibility of weldments to fracture in a brittle manner is studied for an ABS-Class C Steel. The test members have consisted primarily of 12,24 and 36 in. wide notched-and-welded specimens that, at low temperatures, have been known to provide low-stress brittle fractures. The repeated loads or loading history are found to affect the fracture behavior of the weldments. In all but one instance the fracture stresses obtained for the notched-and-welded wide plates were greater than the stresses to which the members had been subjected during the repeated loadings. Furthermore, the repeated load- ings appeared to eliminate the two-stage fractures ob- served in some of the tests of as-welded specimens. This latter condition is in general desirable, but only if the fracture stress is raised to a high-stress level.

Project name is Low-Cycle Fatigue

Munse, WH Cannon, JP Kiefner, JF
Ship Structure Committee, Naval Ship Engineering Center, (SR-149) Final Rpt SSC-188, Oct. 1968, 24pp, 11 Fig, 7 Tab, 5 Phot, 21 Ref

Nobs 88283

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007513

THE VIDEO TAPE RECORDING OF ULTRASONIC TEST INFORMATION

A video tape recorder has been converted into a wide band instrumentation recorder. The A scan from the ultrasonic tester is directly recorded together with the operators voice giving the location, transducer position and interpretation of test data. An oscil- loscope is used for the playback. The circuitry neces- sary to couple the output of the ultrasonic tester to the tape recorder is described.

Youshaw, R Dyer, CH Criscuolo, EL (Naval Ordnance Laboratory)
Ship Structure Committee, Naval Ship Engineering Center, (176) SSC-189, Oct. 1968, 12pp, 6 Fig, 1 Pho, 6 Ref

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AD 677894

007514

BENDING MOMENT DISTRIBUTION IN A MARINER CARGO SHIP MODEL IN REGULAR AND IRREGULAR WAVES OF EXTREME STEEPNESS

An experimental investigation was undertaken to deter- mine (1) the lengthwise vertical wave-bending-moment distribution within the midship half-length and (2) the relationship between bending moment and extreme wave steepness, for a MARINER-type cargo ship. A 1/96-scale model was cut to form six segments, which were joined by a flexure beam. The beam was strain-gaged to measure bending moments at the hull cuts at stations 5, 7 1/2, 10, 12 1/2, and 15. The model was tested with normal weight distribution and with an extreme cargo amidship loading in both head and following seas. The range of regular-wave steepness (height/length) was 0.05 to 0.11; the irregular waves had an equivalent full-size significant height of 39 feet. Within practical operational limits of speed for the MARINER-type ship, the maximum wave bending moments in high regular waves were found to occur in the region from amidship to 0.125L aft of amidships. Thus the practice of concentrating on midship bending moments both in design studies and full-scale measurements appears to be justified for ships of the MARINER-type. Hogging and sagging moments at any section were found to be generally proportional to wave height, up to a wave-height to wave- length ratio of 0.11, the steepest wave that could be generated. The bending-moment and wave data from the test in irregular waves were processed by spectral analysis to obtain equivalent regular-wave responses. These were shown to be, generally, in good enough agreement with the bending-moment response obtained directly in regular waves to inspire confidence in the use of regular-wave response operators and spectral-analysis technique to predict the vertical wave bending moment of a ship in irregular waves

Project name is Bending Moment Determination

Maniar, NM Numata, E
Ship Structure Committee, Naval Ship Engineering Center, (SR-165) Final Rpt SSC-190, Nov. 1968, 33pp, 39 Fig, 3 Tab, 6 Ref

Nobs 88263

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007516

DEVELOPMENT OF MATHEMATICAL MODELS FOR DESCRIBING SHIP STRUCTURAL RESPONSE IN WAVES

Available mathematical models that describe ship-wave interactions are evaluated in order to develop a technique for predicting ship structural response characteristics. Major consideration is given to the bending moment and slamming responses for an arbitrary ship form in any state of sea, at any relative heading and forward speed. The slowly varying vertical and lateral bending moments due to waves are obtained using a linearized model based on strip theory, where the effect of roll motion and its influence in the lateral plane are included, with the model sufficiently general to also allow extension to computation of torsional moments due to waves. Comparison of the results of a limited series of hand computations with available experimental data indicates a good degree of agreement, as well as an overall consistency, for the analysis of wave-induced bending moments. A mathematical representation of the bending moment due to slamming is also described, and computational procedures for obtaining an output compatible with the wave-induced bending moment are outlined. Methods of analysis in terms of power spectra as well as time histories are considered, and the utility of different types of computers for presentation of information on ship structural response is described.

Kaplan, P (Oceanics Incorporated)
Ship Structure Committee, Naval Ship Engineering Center, (174) SSC-193, Jan. 1969, 41pp, 12 Fig, 29 Ref

Nobs-94322

ORDER FROM: NTIS

AD-682591

007517
RECOMMENDED EMERGENCY WELDING PROCEDURE FOR TEMPORARY REPAIRS OF SHIP STEELS
The new merchant cargo ships use a large variety of steels in their construction; the steels range in yield strength from 40 to 100 ksi. Since some of these steels require a close control of the welding procedure as well as other special techniques to assure serviceability, it was felt that a special repair welding procedure must be developed. The procedure must be applicable for all strengths of steel used in construction and should require a minimum amount of procedure control. The recommended temporary welding repair procedure and a discussion of the survey which led to the recommendation are described in this report.

Lowenberg, AL Watson, PD (Southwest Research Institute)
Ship Structure Committee, Department of the Navy SSC-195, May 1969, 12pp, 3 Fig, 1 Tab, 4 Ref

N00024-67-C-5416

ORDER FROM: NTIS

AD 668119

007518
AN INVESTIGATION OF THE UTILITY OF COMPUTER SIMULATION TO PREDICT SHIP STRUCTURAL RESPONSE IN WAVES
Methods of computer simulation of ship structural response in waves are described, with emphasis given to the slowly varying bending moments due to waves and to slamming responses. Analog, digital, and hybrid computer systems are analyzed, and results obtained by use of the most efficient computational procedures for each type of structural response. The vertical and lateral bending moments due to waves are determined by use of a digital computer, and sample computations illustrated for determin- ing frequency domain outputs. Time history outputs of vertical bending moments due to nonlinear slamming are obtained using a modal model of the ship structural dynamic representation, together with time histories of the wave-induced vertical bending moment due to the same wave system. The capabilities of various computer systems to obtain the required responses, the form of the mathematical model appropriate for computational means, and the time requirements for carrying out the operations are also presented. The rapid assessment of spectral responses and their related statistical properties by means of digital computation, together with time history responses at rates faster than real time, provides a useful tool for determin- ing many aspects of ship structural response characteris- tics by means of computer simulation.

Kaplan, P Sargent, TP Raff, AI (Oceanics Incorporated)
Ship Structure Committee, Department of the Navy, (SR-174) Tech Rpt SSC-197, June 1969, 54pp, 24 Fig, 1 Tab, 26 Ref

N00024-67-C-5254

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AD-690229

010311
MIDSHIP WAVE BENDING MOMENTS IN A MODEL OF THE CARGO SHIP WOLVERINE STATE RUNNING AT OBLIQUE HEADINGS IN REGULAR WAVES
Vertical and lateral wave bending moments were measured at the midship section of a 1/96-scale model of the C4-S-B5 cargo ship WOLVERINE STATE. The model was self-propelled through a ship speed-range of 8 to 17 knots at seven headings to regular waves of lengths between 0.3 and 1.8 times the length between perpendiculars/ moderate wave heights not exceeding 1/50 of the model length were used. Results are presented in charts of moment-amplitude/wave-amplitude versus ship speed, with wave length as the parameter. Two ship conditions, light load and full load, are covered.

Chiocco, MJ Numata, E
Stevens Institute of Technology, Ship Structure Committee Tech Rpt SSC-201, Sept. 1969, 22pp, 46 Fig, 3 Tab, 1 Pho, 6 Ref, 1 App

NAVSEC 92299

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010312
SHIP RESPONSE INSTRUMENTATION ABOARD THE CONTAINER VESSEL S. S. BOSTON: RESULTS FROM TWO OPERATIONAL SEASONS IN NORTH ATLANTIC SERVICE
This summary report contains ship response data, with associated discussions, collected during two North Atlantic Winter operating seasons on the Sea-Land container S.S. BOSTON. Seven voyages are covered with sea states ranging to force 12. Maximum vertical bending peak-to-trough stress recorded in the program was 13,400 psi in a sea state of 10. Maximum hull torsional shear stress was 1,800 psi peak-to-trough, also occurring in force 10 seas. Bow vertical acceleration ranged as high as 1.5g and horizontal acceleration as high as .96g. Results of an extensive static loading experiment are also presented and compare well with analytical calculations based on applied loads. Vertical bending data collected on the S.S. BOSTON are compared with that collected on a similar unconverted C4, the S. S. WOLVERINE STATE.

Cragin, JQ
Teledyne Materials Research Company, Ship Structure Committee Final Rpt SSC-214, 1970, 30pp, 28 Fig, 5 Tab, 7 Ref, 1 App

N00024-70-C-5182

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AD-712187

010313
A GUIDE FOR ULTRASONIC TESTING AND EVALUATION OF WELD FLAWS
This document presents procedures and acceptance limits for contact ultrasonic inspection of steel butt welds in the thickness range of 1/4 to 2 inches. The acceptance limits described in the following sections are compatible with those set forth in SSC-117, Guide for Interpretation of Nondestructive Tests of Welds in Ship Hull Structures for radiographic inspection and should therefore result in satisfactory ship welds.

Youshaw, RA
Naval Ordnance Laboratory, Ship Structure Committee Final Rpt SSC-213, 1970, 12pp, 14 Fig

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010314
SHIP RESPONSE INSTRUMENTATION ABOARD THE CONTAINER VESSEL SS BOSTON: RESULTS FROM THE FIRST OPERATIONAL SEASON IN NORTH ATLANTIC SERVICE
This report contains data, with associated discussions, collected from the SEA-LAND Vessel SS Boston, during the winter operating season, November 1968 to Apirl 1969 in the North Atlantic. A total of 356, 15-minute data intervals were obtained, and three wave buoy launches were performed. Plots of various transducer outputs versus Beaufort sea state are provided along with comparisons with data from a similar class of vessel.

Fain, RA Cragin, JQ Schofield, BH
Teledyne Materials Research Company, Ship Structure Committee Tech Rpt SSC-212, 1970, 38pp, 23 Fig, 10 Tab, 4 Ref, 2 App

N00024-68-C-5486

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010316
RESULTS FROM FULL-SCALE MEASUREMENTS OF MIDSHIP BENDING STRESSES ON THREE DRY CARGO SHIPS
This report summarizes the activities undertaken by Teledyne Materials Research under Ship Structure Committee Project SR-153 during a three and one-half year period to investigate certain aspects of the structural response of three dry-cargo ships to wave loads. This work continues earlier studies sponsored by the Ship Structure Committee. Work is concluding on Mormacscan and California Bear and will continue on Wolverine State which is also instrumented to gather data for project SR-172, Slamming Studies to be reported under separate cover.

Walters, IJ Bailey, FC
Teledyne Materials Research Company, Ship Structure Committee SSC-209, 1970, 73pp, 62 Fig, 2 Tab, 5 Ref, 3 App

NObs 94252

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010317

SLAMMING OF SHIPS: A CRITICAL REVIEW OF THE CURRENT STATE OF KNOWLEDGE

This critical review of the current status of the knowledge of bottom slamming phenomena was undertaken to assure that maximum value will be gleaned from recorded data obtained on the SS Wolverine State. The review covers experimental laboratory and ship data and their correlation with available theory; statistical considerations in slamming and in the ocean environment; and structural implications and possible design improvements. Although there are certain areas in the theory which require expansion, the most pressing need is for additional full-scale experimental data to provide confirmation of existing analytical techniques.

Henry, JR Bailey, FC
Teledyne Materials Research Company, Ship Structure Committee SSC-208, 1970, 38pp, 9 Fig, 81 Ref

Nobs 94252

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010319

PERMISSIBLE STRESSES AND THEIR LIMITATIONS

Various aspects of capability and demand of ships such as extreme loads, cyclic loads, plastic design, crack design, collapse and damage are discussed in an attempt to make a synthesis. It is explained that whenever permissible stresses are used in structural design, they should be bounded by probability-concepts, deformation criteria and critical crack lengths. For an acceptable risk factor, the margin between capability and demand seems to be substantial in ships. Yet drastic reductions in structural weight will only be possible if the principle of fail safe design is adopted in shipbuilding to the same extent as in aeroplane-building.

Nibbering, JJW
Delft University of Technology SSC-206, 1970, 15pp, 15 Fig, 17 Ref

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010320

STRUCTURAL DESIGN REVIEW OF LONG, CYLINDRICAL, LIQUID-FILLED INDEPENDENT CARGO TANK BARGES

This report describes a program of analytical research to determine the availability of reliable methods for the design of long, large diameter, cylindrical tanks and their supports for transportation of liquids and low-pressure liquefied gases in barges for service on rivers or at sea. Loading conditions, existing design/analysis methods, material considerations, and a computer method for predicting stresses are presented. The major conclusion of the work performed is that design procedures for river barge tanks up to 20 feet in diameter are well established and that no failures due to inadequate design practice have been reported since refrigerated tanks went into service ten years ago. The present method for designing river barge tanks is a logical starting point for determining the structural configuration of large tanks for oceanic service, but more detailed analysis of loads and resulting stresses should be performed for this application. Several areas in which theoretical or experimental effort is needed are identified: (1) investigation of tank-saddle-barge interaction, (2) investigation of fatigue criteria for cyclic loading, (3) investigation of buckling criteria, (4) analytical and experimental investigation of slamming, and (5) experimental verification of stresses in a full-scale tank.

Bascom, CW
General Dynamics Corporation, Ship Structure Committee SSC-205, 1970, 102 pp, 26 Fig., 14 Tab., 27 Ref., 4 App.

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010321

MIDSHIP WAVE BENDING MOMENTS IN A MODEL OF THE CARGO SHIP CALIFORNIA BEAR RUNNING AT OBLIQUE HEADINGS IN REGULAR WAVES

Vertical and lateral wave bending moments were measured at the midship section of a 1/96-scale model of the C4-S-1A Mariner-class cargo ship California Bear. The model was self propelled through a ship speed-range of 10 to 22 knots at seven headings to regular waves of lengths between 0.2 and 2.0 times the length between perpendiculars; moderate wave heights not exceeding 1/50 of the model length were used. Results are presented in charts of bending-moment-amplitude/wave-amplitude versus ship speed, with wave length as the parameter. Two ship loading conditions, representative of actual westbound and eastbound trans-Pacific voyages are covered.

Numata, E Yonkers, WF
Stevens Institute of Technology, Ship Structure Committee SSC-202, Nov. 1969, 29pp, 19 Fig, 1 Tab, 7 Ref, 1 App

N00024-67-C-5218

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010322

SIMULATED PERFORMANCE TESTING FOR SHIP STRUCTURE COMPONENTS

In this report, the results obtained from wide-plate tension tests undertaken for the purpose of simulating the full-scale performance of steel used in ships hulls are presented. Information as to initiation and propagation of fast fracture in wide steel plates was first obtained through a series of nineteen tests performed on a newly developed wide-plate testing machine. The test material was the pressure vessel steel, ASTM A212 Grade B in 3/4-inch thickness. This information, and the techniques developed, were then applied to a total of eighteen tests using ABS Class C steel, having a thickness of 1-3/8-inch. All specimens were 10 feet wide and 3 were stiffened longitudinally. Test temperatures ranged from-100 degrees F to a room temperature ambient of plus 75 degress F. A fatigue crack or a brittle bead was used as a crack initiator and large residual stresses were introduced. In general, the tests indicated that, at sufficiently low temperatures, a fast fracture could be produced in ASTM A212 Grade B and ABS Class C steels if a sufficiently sharp initiation site was located within an area of relatively high applied and/or residual stress. Based on the results of the tests conducted, it is concluded that the ABS Class C material is not sensitive to fast fracture at temperatures well below service tmeperatures. Therefore, this material may be used to effect a fracture safe design for modern ship hulls.

Sherman, R
Southwest Research Institute, Ship Structure Committee SSC-204, 1970, 64 pp, 12 Fig., 2 Tab., 12 Ref., 3 App.

NObs 92294

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015222

A GUIDE FOR THE SYNTHESIS OF SHIP STRUCTURES. PART ONE THE MIDSHIP HOLD OF A TRANSVERSELY-FRAMED DRY CARGO SHIP

This report presents the design synthesis for a digital computer program that has been developed, based on the application of rational techniques, for the design of the optimum midship structure of a transversely-framed dry cargo ship. The merit of the design method used is that all empirical knowledge on the proportioning of hull structure to withstand the forces of the seaway finds expression in three factors namely: separation of structure into primary, secondary and tertiary components. The program is subject to the following qualifications: a) external loadings and wave induced bending moment must be entered as input data b) design criteria are arbitrary and based solely on the overall strength of the hull c) stress intensities under distributed loadings do not exceed the elastic limit of the material d) the ship steams upright in head or following seas e) impulsive loading from slamming is not taken into account explicitely, nor are stress concentrations, strength under localized loading, rigidity and corrosion allowances, inter alia.

St. Denis, M
National Engineering Science Company, Naval Ship Engineering Center,

(SSC-215) SSC-215, Oct. 1970, 113pp, 10 Fig, 11 Tab, 20 Ref, 15 app

N00024-67-C-5315

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015339

ANALYSIS OF SLAMMING DATA FROM THE S.S. WOLVERINE STATE

The stress recording system aboard the S.S. Wolverine State was expanded to include pressure transducers and accelerometers. Stress, pressure, and acceleration signals were recorded on magnetic tape over a period of three years, and data on hundreds of slams were recorded. Slamming occurred only at Beaufort numbers above 5, and under relative headings within about 30 degrees of head seas. Reduction of speed did not appear to reduce the frequency of slamming, but the forward draft was a significant factor. Ochis predictions of the statistical distribution of slamming occurrences were confirmed, as were his model data relating pressure and relative velocity at impact. The bow acceleration was found to be a sensitive indicator of slamming phenomena, and relationships between acceleration, velocity, and pressure were established. Slamming pressure levels were consistent with ship model test results, but were less than other full-scale and drop-test data reported in the literature. (Author)

Wheaton, JW Kano, CH Diamant, PT Bailey, FC
Teledyne Materials Research Company SSC-210, Aug. 1970, 76pp
N00024-68-C-5231

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015365

COMPRESSIVE STRENGTH OF SHIP HULL GIRDERS. PART I. UNSTIFFENED PLATES

Three problem areas of Hull girder strength are biaxial strength (to account for the transverse membrane loadings induced by the sea), the influence of normal pressure loadings on strength, and the influence of strength of residual stresses induced by welding. Data on solutions to these problems were obtained during this project. (Author)

Becker, H Goldman, R Pozerycki, J
Mithras SSC-217, 1970, 73pp

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024840

DESIGN CONSIDERATIONS FOR ALUMINUM HULL STRUCTURES--STUDY OF ALUMINUM BULK CARRIER

The study was undertaken to evaluate the benefits and constraints that will develop when ship design as well as fabrication procedures are modified to employ aluminum alloys instead of steel for hull structure of a large deadweight carrier. The fabrication of a large aluminum hull with state of the art materials and construction techniques is shown to be technically feasible. Present 5000 series alloys have adequate properties, though additional research is required, particularly into fatigue characteristics. Experience to date with existing aluminum ships has been good, though instances of cracking at welds and corrosion have been noted. Criteria for the design of the aluminum hull structure are presented and justified. Methods of fire protection and system/equipment installation are evaluated, and operational characteristics of an aluminum bulk carrier are reviewed. The designs of a large aluminum bulk carrier and an equivalent steel ship are presented and compared. The aluminum ship's structure weighs 43 percent less than the steel ship, and its hull is about 50 percent more flexible. Cargo deadweight is increased 7-1/2 percent. (Author)

Altenburg, CJ Scott, RJ
Gibbs and Cox, Incorporated SSC-218, 16671/(1-598), 1971, 140pp

N00024-70-C-5138

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025621

CRACK PROPAGATION AND ARREST IN SHIP AND OTHER STEELS

The program was undertaken to explore the possibility of measuring and analyzing crack propagation and arrest. These processes depend on a number of factors (1) the mechanics of the flawed structure (or test specimen), (2) the plastically deformed zone at the crack tip, (3) the metal's resistance to plastic flow and its rate dependence, and (4) the processes of cleavage and ductile rupture on the microstructural scale. The work sought numerical descriptions of the individual factors with the aim of assembling these into a comprehensive systems-type analysis of propagation and arrest. The studies employed the DCB (double-cantilever-beam) test specimen because this configuration offers the possibility of initiating, propagating, and arresting a fast fracture, under controlled conditions, within the confines of a single specimen. Analyses of the stress fields of stationary cracks in DCB specimens are reported. (Author)

Hahn, GT Hoagland, RG Mincer, PV Rosenfield, AR Sarrate, M
Battelle Memorial Institute Final Rpt SSC-219, Aug. 1971, 63pp

Contract N00024-68-C-5073

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028580

CATAMARANS-TECHNOLOGICAL LIMITS TO SIZE AND APPRAISAL OF STRUCTURAL DESIGN INFORMATION AND PROCEDURES

Existing United States shipbuilding facilities can handle 1000-foot catamarans with up to 140-foot individual hull beams on the premise that the hulls would be joined afloat. Major harbors and channels of the world suggest an overall beam limit of 400 feet and 35-foot draft. Drydocking for catamarans over 140-foot in breadth will require new facilities or extensive modification to existing facilities. Scantlings of 1000-foot catamaran cargo liner can be expected to be within current shipbuilding capabilities. The uniqueness of the catamaran design lies in the cross-structure and the important facets of the cross-structure design are the prediction of the wave-induced loads and the method of structural analysis. The primary loads are the transverse vertical bending moments, axial force, shear, and torsion moments. Designers have relied heavily on model tests to obtain design loads and have used general structures principles and individual ingenuity to perform the structural analysis in the absence of established guidelines. Simple semi-empirical equations are proposed for predicting maximum primary loads. A structural analysis method such as the one proposed by Lankford may be employed for conceptual design purposes. The Lankford method assumes the hulls to be rigid and the cross- structure loads to be absorbed by a group of transverse bulkheads and associated effective deck plating. This procedure in general should provide an overall conservative design and not necessarily an economic or optimized design. Additional research and development work including systematic model test programs are necessary for accumulating additional knowledge in areas of uncertainty and for the establishment of reliable design methods for catamaran structure.

Maniar, NM Chiang, WP
Rosenblatt (M) and Son, Incorporated SSC-222, Sept. 1971, 69pp, 24 Ref

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028778

COMPRESSIVE STRENGTH OF SHIP HULL GIRDERS. PART II. STIFFENED PLATES

This is Part II of a two-part report on a year of investigation into the compressive strength of ship hull girders. This part covers stiffened mild steel plates with a/b equal 3 and b/t equal 50. Seven tests were conducted on panels and grillages loaded in axial compression in various combinations with transverse membrane compression and normal pressure. In addition, a three-girder was tested in pure bending. One of the prime goals of the project was to determine the strength of plates in grillages and girders as compared to the square tube behavior described in Part I. From an engineering viewpoint there was little difference between the square tube strengths and the strengths of plates in the stiffener-plate configurations. The

results revealed an increase in plate strength of 4-1/2 percent compared to the tube test data for uniaxial compression loading without normal pressure, and a reduction of 1 percent when tested in uniaxial compression plus normal pressure. The girder strength was 3.7 percent above the tube strength. The effect of biaxiality may have reduced the longitudinal strengths of the grillages compared to the tube data. However, the reduction could have been a few percent at most. A single panel in uniaxial compression was 7.1 percent stronger than the corresponding tube. All the studies in this phase were performed on electron-beam-welded plate assemblies of which a 0.030 inch thick mild steel plate was the basic element. The plates between stiffeners were 1.50 inches wide (b/t equal 50) and 4.50 inches long (a/b equal 3). These nominal dimensions are the same as the plates which comprised the faces of the tubes for b/t equal 50 which were tested during the Part I investigation. The stiffeners were designed to insure achievement of maximum plate strength. Strain data were recorded to check stress distributions for general uniformity.

Becker, H Colao, A Goldman, R Pozerycki, J
Sanders Associates, Incorporated Final Rpt SSC-223, 1971, 23pp, 11 Fig, 3 Ref, 1 App

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028999

RESPONSE OF THE DELTA TEST TO SPECIMEN VARIABLES

The Delta specimen has been applied to two different heats of A517 grade steel in one inch plate thickness and to the one heat in 1/2 and 2 inch plate thickness. Various modifications of the basic specimen have been investigated, a non-standard geometry and a composite form of the specimen into which different steel types were incorporated. The influences of various welding procedures have been examined as well as the performance of all steels in the non-welded condition. The specimen was found applicable and appropriate for all conditions tested, showing sensitivity to all variables. At the same time the specimen showed a consistency in behavior which could be rationalized with commercial experience and data from corollary tests. The steels examined showed several transitional behaviors when tested as weldments, these transitions occurring in place of fracture, length of fracture, load carrying changes and overall ductility measured by deflection at failure.

Performed under Naval Ship Engineering Center Contract No. N00024-C-5463.

McGeady, LJ
Lafayette College SSC-221, Sept. 1971, 42pp, 2 Ref

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032202

FEASIBILITY STUDY OF GLASS REINFORCED PLASTIC CARGO SHIP

The report describes a study undertaken to evaluate the technical and economic feasibility of constructing and operating a large glass reinforced plastic (GRP) cargo vessel or, alternatively, using GRP for major structural components on a steel cargo ship. Areas for further research are presented, and further investigations of smaller GRP vessels (150-250 feet long) are proposed since these appear most promising at this time. (Author)

Scott, RJ Sommella, J
Gibbs and Cox, Incorporated SSC-224, 1971, 135pp

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040595

STRUCTURAL ANALYSIS OF LONGITUDINALLY FRAMED SHIPS

The technique of finite elements has brought about a new era in the field of structural analysis of ship structures. The application of this technique, however, is limited by the cost and capacity of the computer. Straightforward appli- cations of the finite element method to the whole or to a major portion of the ship have so far been inaccurate and too expensive for design purposes. The method presented combines the advantages of the finite element technique and the uncoupling by coordinate transformation. A fine mesh may now be used to produce more accurate boundary conditions. The uncoupling transformations also reduce the computer time to about one-tenth of that by other methods. The critical assumptions and the basic theories have been verified with experimental test results from the tanker "JOHN A. MCCONE." This report discusses three computer programs; one for the longitudinal strength analysis, one for transverse strength analysis, and one for the local stability check of the structure. The programs themselves appear in subsequent reports.

Nielson, R Chang, PY Deschamps, LC (Com-Code Corporation)
Ship Structure Committee SSC-225, July 1972, 60 pp, 21 Ref

Contract N00024-70-C-5219

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040596

TANKER LONGITUDINAL STRENGTH ANALYSIS--USER'S MANUAL AND COMPUTER PROGRAM

This report, the second in a sequence of four Ship Structure Committee Reports on a method for performing structural analysis of a tanker hull, contains the User's Manual and Computer Program for the longitudinal strength analysis portion of the program.

Nielson, R Chang, PY Deschamps, LC (Com-Code Corporation)
Ship Structure Committee SSC-226, July 1972, 10 pp

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040597

TANKER TRANSVERSE STRENGTH ANALYSIS--USER'S MANUAL

This report, the third in a sequence of four Ship Structure Committee Reports on a method for performing structural analysis of a tanker hull, contains the User's Manual for the transverse strength analysis portion of the program.

Nielson, R Chang, PY Deschamps, LC (Com-Code Corporation)
Ship Structure Committee SSC-227, July 1972, 43 pp

Contract N00024-70-C-5219

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040598

TANKER TRANSVERSE STRENGTH ANALYSIS--PROGRAMMER'S MANUAL

This report, the last in a sequence of four Ship Structure Committee Reports on a method for performing structural analysis of a tanker hull, contains the Programmer's Manual for the transverse strength analysis portion of the program.

Nielson, R Chang, PY Deschamps, LC (Com-Code Corporation)
Ship Structure Committee SSC-228, July 1972, 43 pp

Contract N00024-70-C-5219

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040599

EVALUATION AND VERIFICATION OF COMPUTER CALCULATIONS OF WAVE-INDUCED SHIP STRUCTURAL LOADS

An analytical method for the determination of conventional merchant ship

motions and wave-induced moments in a seaway is developed. Both vertical and lateral plane motions and loads are considered for a ship travelling at any heading in regular waves and in irregular long or short crested seas. Strip theory is used and each ship hull cross-section is assumed to be of Lewis form shape for the purpose of calculating hydrodynamic added mass and damping forces in vertical, lateral and rolling oscillation modes. The coupled equations of motion are linear, and the superposition principle is used for statistical response calculations in irregular seas. All three primary ship hull loadings are determined, i.e. vertical bending, lateral bending and torsional moments, as well as shear forces, at any point along the length, with these responses only representing the low frequency slowly varying wave loads directly induced by the waves. A computer program that carries out the calculations was developed, and is fully documented separately. The results of the method are evaluated by comparison with a large body of model test data. The comparison extends over a wide range of ship speeds, wave angles, wave lengths, and loading conditions, as well as hull forms. The agreement between the calculations and experimental data is generally very good. Thus, a method is available for use in the rational design of the ship hull main girder structure.

Kaplan, P Raff, AI (Oceanics, Incorporated)
Ship Structure Committee SSC-229, July 1972, 50 pp

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040600
PROGRAM SCORES--SHIP STRUCTURAL RESPONSE IN WAVES

Information necessary for the use of the SCORES digital computer program is given. This program calculates both the vertical and lateral plane motions and applied loads of a ship in waves. Strip theory is used and each ship hull cross-section is assumed to be of Lewis form for the purpose of calculating hydrodynamic forces. The ship can be at any heading, relative to the wave direction. Both regular and irregular wave results can be obtained, including short crested seas (directional wave spectrum). All three primary ship hull loadings are computed, i.e. vertical bending, lateral bending and torsional moments. All the basic equations used in the analysis are given, as well as a description of the overall program structure. The input data requirements and format are specified. Sample input and output are shown. The Appendices include a description of the FORTRAN program organization, together with flowcharts and complete cross-referenced listing of the source language.

Raff, AI (Oceanics, Incorporated)
Ship Structure Committee SSC-230, July 1972, 63 pp

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040601
FURTHER STUDIES OF COMPUTER SIMULATION OF SLAMMING AND OTHER WAVE-INDUCED VIBRATORY STRUCTURAL LOADINGS ON SHIPS IN WAVES

Results of analytical modeling and computer simulation of wave-induced structural loadings on ships in waves is presented, with consideration of bow flare slamming, bottom impact slamming, and springing. Consideration is given only to the case of head seas, and the outputs are obtained in the form of time histories due to the nature of the nonlinearities and the nonstationary properties associated with the slamming phenomena. Springing is considered to be linear and statistically stationary, and output in either time history or spectral form is possible, with the same r.m.s. value obtained by either technique. Time history simulation of the slowly-varying direct wave-induced vertical bending moment is also provided, so that relations between constituents making up the total vertical bending moment are demonstrated. The output data is available at rates appreciably faster than real time (80 times or more faster) by use of a large commercial general purpose digital computer, thereby allowing rapid analysis of ship structural loads via computer simulation. The present results are primarily demonstrative of capability. Particular refinements in the manner of representing local forces, theoretical techniques for valuation of such forces, and computational procedures, etc. that are necessary for producing a final completed program for calculation of such loads on a routine basis, are described in the report.

Kaplan, P (Oceanics, Incorporated); Sargent, TP
Ship Structure Committee SSC-231, July 1972, 36 pp, 23 Ref

Contract N00024-70-C-5076

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040602
STUDY OF THE FACTORS WHICH AFFECT THE ADEQUACY OF HIGH-STRENGTH, LOW-ALLOY STEEL WELDMENTS FOR CARGO SHIP HULLS

High-strength, low-alloy quenched and tempered steels of 100,000-psi minimum yield strength are being used in ship hull structures. A project was initiated by the Ship Structure Committee to define which mechanical properties should be used as performance criteria, to evaluate the suitability of these criteria with large-scale test weldments, and to select small-scale laboratory tests that correlate with the large-scale tests. A survey of available mechanical property data and of the use of these materials at various shipyards led to the recommendation that certain laboratory investigations be conducted. This report describes the results of both small-scale and large-scale tests conducted on high-strength, low-alloy plate and weldments. These tests demonstrated that 8 in. long flaws can initiate fast fracture at stresses below the yield strength of the material, that structural fracture resistance is increased by stiffeners, and that weldments can have fracture resistance equal to that of the base plate.

Norris, EB Pickett, AG Wylie, RD (Southwest Research Institute)
Ship Structure Committee SSC-232, July 1972, 30 pp, 5 Ref

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040603
CORRELATION OF MODEL AND FULL-SCALE RESULTS IN PREDICTING WAVE BENDING MOMENT TRENDS

Comparison is made between model and full-scale predictions of long-term wave-induced bending moment trends for two ships, the S.S. WOLVERINE STATE and the S.S. CALIFORNIA BEAR. For predicting such statistical trends of wave bending moment from model tests two basic types of required data are discussed: a. Wave data from different levels of sea severity, along with relationships between wave heights and wind speeds. b. Model response amplitude operators as a function of ship loading condition, speed and heading. Available wave data in different ocean areas are first reviewed. The determination of the wave bending moment responses, and the expansion to full-scale are then shown and discussed. Comparison of predicted long-term trends with extrapolated full-scale results shows good agreement for the WOLVERINE STATE in the North Atlantic and fair results for the CALIFORNIA BEAR in the North Pacific. The inferiority of the latter is probably due to less refined definition of the sea in this ocean area. It is concluded that success in using the prediction method presented is a function of the quality of sea data available for the particular service in question.

Hoffman, D Williamson, J Lewis, EV (Webb Institute of Naval Architecture)
Ship Structure Committee SSC-233, July 1972, 62 pp, 26 Ref, 2 App

Contract N00024-68-C-5282

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040604
EVALUATION OF METHODS FOR EXTRAPOLATION OF SHIP BENDING STRESS DATA

This report is a continuation of an earlier report (Report SSC-196, June 1969), giving results of the analysis of all available stress data from full-scale measurements on the following dry cargo ships: S. S. WOLVERINE STATE, S.S. HOOSIER STATE, S.S. MORMACSCAN, and S.S. CALIFORNIA BEAR. The results for the first two, which are sister ships of the C4-S-B5 type cover a total of about 10 ship-years in the North Atlantic, and

results are felt to be consistent and reliable. Results for the MORMAC-SCAN, covering brief periods in the runs from New York to Europe and New York to South America, appear to provide inadequate statistical samples. CALIFORNIA BEAR results for the North Pacific appear to be reasonable for that service. Further details are given on two techniques for the analysis and extrapolation of full-scale data to longer periods of time, in order to predict extreme bending stresses (or bending moments) in service. One of the techniques employs the integration of rms stress data from individual stress records; the other makes use of the highest stresses obtained in each record (extreme values). Both techniques involve the classification of data by severity of weather in order to obtain greater generality of results. It is shown that extrapolated trends from two methods are consistent. Comparisons are made of non-dimensional bending moment coefficients for all of the ships on the basis of the same "standard" weather distribution.

Hoffman, D Van Hooff, R Lewis, EV (Webb Institute of Naval Architecture)
Ship Structure Committee SSC-234, Aug. 1972, 41 pp, 15 Ref

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051223
A METHOD FOR DIGITIZING, PREPARING AND USING LIBRARY TAPES OF SHIP STRESS AND ENVIRONMENT DATA. PART I
Midship bending stress and environmental data from four dry-cargo ships, accumulated during the period 1959 through early 1970 under Ship Structure Committee Project SR-153, Ship Response Statistics, have been processed and written on digital magnetic tapes. During the processing, selected statistical information was derived which has been included on the digital tapes for each of the 13220 intervals recorded. The original FM analog data were contained on 163 reels of magnetic tape. The entire collection is now stored on 25 reels of digital tape and pertinent reduced data from each interval are stored on two summary reels. Processor programs were written to convert the original analog data and environmental information to the final digital format and to provide a capability to extract portions of the data for subsequent statistical analysis. (Author)
Report on Ship Response Data Study.

Johnson, AE, Jr Flaherty, JA Walters, IJ
Teledyne Materials Research Company, (SR-187) Tech Rpt. SSC-236, E-1149 (c), Feb. 1973, 63 pp

Contract N00024-69-C-5161

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051224
LOAD CRITERIA FOR SHIP STRUCTURAL DESIGN
Consideration is given to the critical loads on ships' hulls, as indicated by possible modes of structural damage and/or failure. An ultimate load criterion is then set up involving the following bending moments: quasi-static wave-induced, vertical and lateral combined, still water, including effect of ship's own wave, dynamic loads, including slamming, whipping, and springing, and thermal effects. The determination of each of these loads is discussed in detail, and the need for further clarification of dynamic loads is brought out. Methods of combining these loads, all expressed in probability terms, are considered. A criterion for cyclic loading is discussed, involving the prediction of the expected number of combined loads of different levels, as well as the expected shifts of mean value. A criterion for brittle fracture is also discussed. Attention is given to estimating an acceptable probability of failure for use in design. Finally, calculations of loads are carried out for a typical cargo ship, the S.S. Wolverine State. The loads are then combined in accordance with the proposed ultimate load criterion and compared with the standards under which the ship was designed. (Author)

Lewis, EV Hoffman, D Maclean, WM van Hooff, R Zubaly, RB
Webb Institute of Naval Architecture, (SR198) Tech Rpt. SSC-240, May 1973, 118p

Contract N00024-71-C-5372

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AD-767389/0

052139
FAST FRACTURE RESISTANCE AND CRACK ARREST IN STRUCTURAL STEELS
This report presents findings of an Army Research Office supported study concerned with the response of high-strength steels to fast running cracks, and a separate Ship Structure Committee program dealing with unstable fractures in ship plates. Together, the results provide a new basis for measuring and characterizing the properties of structural alloys that control fast fracture and crack arrest. Measurements and calculations of unstable fracture and fracture arrest in 12.7 mm-and 25.4 mm-thick, high-strength SAE4340 steel and A517F steel plates are described. The unstable fractures which propagated at steady-state velocities in the range 185 m/s to 1180 m/s were produced in wedge-loaded DCB-(double-cantilever-beam) test specimens. The study demonstrates a new concept: the "duplex" DCB-specimen. A fully dynamic analysis of unstable crack propagation and arrest in the DCB-test piece is derived. The technique is based on the beam-on-elastic foundation model of the DCB specimen used previously but with the simple beam and foundation representations replaced by a Timoshenko beam and a generalized elastic foundation. Crack speeds, energy levels, and the crack length at arrest are calculated with this model using a finite-difference method and are compared with the measurements.
Progress report on Fracture Arrest Study (SR-201), MRIS 052047-23A.

Hahn, GT Hoagland, RG Kanninen, M Rosenfield, AR Sejnoha, R (Battelle Memorial Institute)
Ship Structure Committee Prog Rpt SSC-242, Dec. 1973, 113 pp, 72 Ref, 5 App

Contract N00024-72-C-5142

ORDER FROM: NTIS

AD 775018

052227
THERMOELASTIC MODEL STUDIES OF CRYOGENIC TANKER STRUCTURES
Theoretical calculations and experimental model studies were conducted on the problem of temperature and stress determination in a cryogenic tanker when a hold is suddenly exposed to the chilling action of the cold fluid. The initiation of the action is presumed to be the sudden and complete rupture of the fluid tank. Model studies of temperatures and stresses were performed on instrumented steel versions of a ship with center holds and wing tanks. (Modified author abstract)

Becker, H Colao, A
Sanders Associates, Incorporated, (SR-191) Final Rpt. SSC-241, Aug. 1973, 87 pp

Contract N00024-70-C-5119

ORDER FROM: NTIS

AD-771217/7

054826
EFFECT OF TEMPERATURE AND STRAIN UPON SHIP STEELS
The effects of flame straightening and both hot and cold forming upon material properties of hot rolled, normalized, and quenched and tempered steels were investigated. Flame straightening was studied by first simulating the effects of time at temperature upon the tensile and impact properties of seven steels. Straightening was then performed within the determined limits upon 4-foot-square plates which had been distorted by welding them into a rigid frame. As a result of these studies, it is recommended that flame straightening with appropriate controls be allowed as an acceptable process for distortion removal for both normalized and quenched and tempered steels. Simulations of outer fiber strain resulting from both hot and cold forming were conducted to determine the effects of temperature and strain

upon properties. In general, it was found that either tensile or impact properties were reduced to some degree by most operations.

Rothman, RL Monroe, RE
Ship Structure Committee Res. Rpt. SSC-235, Mar. 1973, 29 pp

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AD-768891/4

057756
WAVE LOADS IN A MODEL OF THE SL-7 CONTAINERSHIP RUNNING AT OBLIQUE HEADINGS IN REGULAR WAVES (SL-7-2)

Vertical, lateral and torsional wave bending moments, and vertical and lateral shears were measured at two sections of a 1/140-scale model of the SL-7 containership. The model was self-propelled through a ship speed range of 24 and 32 knots at seven headings to regular waves of lengths between 0.25 and 2.0 times the length between perpendiculars. Motions were also measured. Two ship conditions: light and full load were covered. Results are presented in charts of load or motions amplitude/wave amplitude vs. wave length and phase lag vs. wave length, with heading, ship speed and loading condition as parameters. (Author)

Dalzell, JF Chiocco, MJ
Stevens Institute of Technology Final Rpt. SSC-239, SIT-DL-71-1613, 1973, 79 pp

Contract N00024-71-C-5489

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AD-780065/9

057757
DESIGN AND INSTALLATION OF A SHIP RESPONSE INSTRUMENTATION SYSTEM ABOARD THE SL-7 CLASS CONTAINERSHIP S.S. SEA-LAND MCLEAN (SL-7-1)

The report describes the transducers, cabling, signal-conditioning, and recording elements of the instrumentation system installed aboard the SL-7 Containership S.S. SEA-LAND McLEAN. It includes a detailed summary of the strain-gage bridge circuits, locations of all transducers, and a description of the various operating modes and options available for recording data from more than 100 strain gages, accelerometers, and motion sensors. (Author)

Fain, RA
Teledyne Materials Research Company Tech. Rpt. SSC-238, E-1395 (b), June 1973, 46 pp

Contract N00024-73-C-5059

ORDER FROM: NTIS

AD-780090/7

084427
THEORETICAL ESTIMATES OF WAVE LOADS ON THE SL-7 CONTAINER SHIP IN REGULAR AND IRREGULAR SEAS (SL-7-4)

The computer program SCORES for predicting ship structural response in waves is applied to the SL-7 container ship. The operating conditions considered are 2 displacements, 4 ship speeds, 21 wavelengths, 19 headings and 5 sea states assuming both long-crested and short-crested seas. These results constitute a complete data bank for the SL-7 ship in the form of both frequency responses for regular waves as well as rms and other statistical response measures for irregular seas. Comparison is made between the computer and model tests of the SL-7 in regular waves in predicting vertical, lateral and torsional moments, and vertical and lateral shears at two sections and heave, pitch and roll. Regions where the theory and model experiment do not agree have been pointed out and some means of correction or extension of the theory is discussed.

This is a technical report on project SR-205, "Ship Computer Response".

Kaplan, P Sargent, TP Cilmi, J
Ship Structure Committee SSC-246, 1974, 62 pp, 10 Ref.

Contract N00024-70-C-5076

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AD/A-004554/2

084835
STRUCTURAL ANALYSIS OF SL-7 CONTAINERSHIP UNDER COMBINED LOADING OF VERTICAL, LATERAL AND TORSIONAL MOMENTS USING FINITE ELEMENT TECHNIQUES (SL-7-3)

The entire SL-7 container vessel hull structure is analyzed by the DAISY finite element computer program. The ship, loaded with containers, placed in oblique quasi-static regular waves, is subject to combined vertical, lateral and torsional loads. Stress distributions particularly in the deck region are presented and investigated from the analysis using the reduced element substructure feature in the program. Fine mesh analyses are also presented at different locations of the ships. The computer stresses are discussed in connection with the placement of strain gages instrumentation on the 'SEA-LAND MCLEAN'.

Elbatouti, AM Liu, D Jan, HY
United States Coast Guard, Sea-Land Service, Incorporated, American Bureau of Shipping SSC-243, May 1974, 59 pp

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AD/A-002620/3SL

084840
FLAME STRAIGHTENING QUENCHED AND TEMPERED STEELS IN SHIP CONSTRUCTION

Flame straightening quenched-and-tempered steel procedures were successfully employed by trained shipyard personnel on portions of a LASH (Lighter Aboard Ship) ship under construction with minimal acceptable loss in mechanical properties and with considerable savings in time and money. Test checks were conducted in the laboratory with simulated experiments on steel panels 150 inches by 48 inches by 5/16 inch and stiffened by angles at 30-inch intervals. As much as two inches of unfairness of the plating was effectively removed. A recommended procedure is presented.

Rothman, RL
Battelle Columbus Laboratories, United States Coast Guard Final Rpt. SSC-247, 1974, 22 pp

Contract N00024-73-C-5173

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AD/A-002621/1SL

092194
A STUDY OF SUBCRITICAL CRACK GROWTH IN SHIP STEELS

The report presents an evaluation of the potential problems associated with crack initiation and subcritical crack growth in high strength, low alloy steels used in welded ship structure. An interpretive review of the state-of-the-art is given, emphasizing design tools that are available and their potential for use in fail safe or safe crack growth ship design philosophy. A crack initiation and crack growth criterion is presented, which permits welded ship structure to be designed with confidence that serious failures can be avoided, while at the same time full use of the attractive static properties of HSLA steels can be exploited. The report also includes a list of problem areas in need of further clarification in order to enhance confidence in the proposed criterion.

Francis, PH Lankford, J. Jr Lyle, FF, Jr
Southwest Research Institute, Ship Structure Committee, Naval Ship Engineering Center, (SR209) Final Rpt. SSC-251, June 1974, 176p

Contract N00024-73-C-5199

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AD-A013970/9ST, DOTL NTIS

095186
FRACTURE TOUGHNESS CHARACTERIZATION OF SHIPBUILDING STEELS

New fracture control guidelines for welded ship hulls have been proposed as a result of an investigation sponsored by the Ship Structure Committee. These guidelines include fracture toughness requirements in terms of the Drop Weight-NDT temperature and Dynamic Tear (DT) energy. To aid the implementation of these criteria an exploratory program was undertaken to characterize the dynamic fracture toughness of ordinary-strength shipbuilding steels, namely, ABS Grades A,B,C,D,E, and CS. Test materials (plate)

were obtained at random from several shipyards and steel mills in an effort to characterize the products of current steel making practice. Fracture toughness trends were defined by means of Drop Weight-NDT, 1-in. DT and standard Charpy V-notch tests and the observed toughness characteristics were compared with the proposed toughness criteria. Non-heat treated plates of ABS Grades A,B, and C were found to have insufficient toughness to meet reasonable fracture toughness requirements. On the other hand, normalized plates ofABS Grades C,D,E, andCS were found to exhibit improved toughness trends that could meet the proposed requirements in most cases.

Hawthorne, JR Loss, FJ
Naval Research Laboratory, (NRL 7701) Final Rpt SSC-248, July 1974, 36 pp, 15 Ref.

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AD-785 034/0

095188
SHIP VIBRATION PREDICTION METHODS AND EVALUATION OF INFLUENCE OF HULL STIFFNESS VARIATION ON VIBRATORY RESPONSE.
Research is conducted to obtain a greater understanding of induced hull vibrations and, more specifically, to define the role of hull stiffness in such phenomena. Available methods for the prediction of vibratory response to propeller, slam and wave excitations are evaluated. The work scope is limited essentially to the vertical vibration of the main hull. Parametric analyses are presented which include the calculations of the propeller, slam-and wave-induced vibrations of three ships with their hull stiffness varying from 40 percent below to 40 percent above the as-built stiffness. The three ships are a 249,300 DWT tank ship, the Great Lakes ore carrier "STR. EDWARD L. RYERSON" and the 544 ft. general cargo ship "S. S. MICHIGAN." Design trends are developed with respect to characteristics that influence ship stiffness and vibratory response. Propeller-induced main hull vibrations for all three ships do not appear to be effected by variations in hull stiffness. Slam-induced vibrations seem to increase and decrease as stiffness increases and decreases. The tank ship and the Great Lakes ore carrier appear to be prone to wave-induced vibration, and increased hull stiffness has a beneficial effect on limiting the response. Further research is required which would lead to engineering methods for the estimation of propeller excitation forces and slam loads which can be used to predict vibration during the design stages. Literature on wave-induced vibration is limited and the subject deserves significant research effort. Particular attention should be paid to the effects of forebody and afterbody shapes and damping.

Kline, RG Daidola, JC
Rosenblatt (M) and Son, Incorporated, (SF 35-422-306) Final Rpt. SSC-249, June 1974, 191 pp, 79 Ref.

Contract N00027-73-C-5206

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AD-A008388

095189
BIBLIOGRAPHY FOR SHIP VIBRATION PREDICTION METHODS AND EVALUATION OF INFLUENCE OF HULL STIFFNESS VARIATION ON VIBRATORY RESPONSE.
The bibliography presented here was prepared in the course of performing the "Hull Flexibility Criteria Study" (SR-214) whose results appear in the report entitled "Ship Vibration Prediction Methods and Evaluation of Influence of Hull Stiffness Variation on Vibratory Response." The reason for publishing the bibliography separately is that it is believed it may be of assistance to locate references in a variety of topics relative to ship vibration not addressed to in Project SR-214. This is not to imply that the bibliography is complete or exhaustive.

Kline, RG Daidola, JC
Rosenblatt (M) and Son, Incorporated Final Rpt. SSC-250, May 1974, 33 pp

Contract N00024-73-C-5206

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AD-A008387

138008
SL-7 INSTRUMENTATION PROGRAM BACKGROUND AND RESEARCH PLAN (SL-7-5)
The SL-7 Instrumentation Program includes measurement of hull stresses, accelerations and environmental and operating data on the S.S. SEA-LAND McLEAN, development and installation of a microwave radar wavemeter for measuring the seaway encountered by the vessel, a wave tank model study and a theoretical hydrodynamic analysis which relate to the wave-induced loads, a structural model study and a finite element structural analysis which relate to the structural response, and installation of long term stress recorders on each of the eight vessels of the class. This report presents an overview of the program. The experimental background upon which the program was based and the major features and expected outputs of each of the program elements are discussed, and some preliminary conclusions drawn from the research results are presented. A detailed description of the possible data correlations and their consequences is included. The long-range goal of the program is to advance understanding of the performance of ships' hull structures and the effectiveness of the analytical and experimental methods used in their design. A research plan to achieve this is outlined.
Report on SL-7 Data Analysis and Correlation.

Siekierka, WJ Johnson, RA Loosmore, CS
Ship Structure Committee Final Rpt. SSC-257, SL-7-5, 1976, 65 pp

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AD-A021 337/1GA

138414
DYNAMIC CRACK PROPAGATION AND ARREST IN STRUCTURAL STEELS
This is the second of two Ship Structure Committee reports describing a three-year investigation of the crack propagation and arrest characteristics of ship-hull steels. The earlier report (SSC-242), which dealt principally with development of experimental and analytical techniques, is briefly discussed. Results are then presented for the following steels: ASTM-A517F (high strength low alloy), 9% Ni (for cryogenic service), ABS-C and ABS-E (two plates, one of which is high strength and designated EH).

Hahn, GT Hoagland, RG Rosenfield, AR
Battelle Columbus Laboratories Final Rpt. SSC-256, 1976, 63 pp

Contract N00034-72-C-5142

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139681
A GUIDE FOR THE NONDESTRUCTIVE TESTING OF NON-BUTT WELDS IN COMMERCIAL SHIPS-PART TWO
This report is in two parts: Part 1 is the guide for the nondestructive testing of non-butt welds in commercial ships. Part 2 documents the technical considerations involved in preparing that guide. Procedures are presented for performing visual inspection, magnetic particle testing, radiography, ultrasonics, and penetrant testing on steel welds in the thickness range of 1/2" to 2-1/2". The basic weld joints considered are the corner joint, the Tee, "X", and the lap joint. A discussion is presented for each of the inspection methods whereby weld quality may be controlled in a meaningful way when there is a need to do so.

Youshaw, RA Criscuolo, EL
Naval Surface Weapons Center, (NOLTR 74-138) Final Rpt SSC-254, Dec. 1974, 23 pp, 8 Ref.

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AD-A014548

139903
VERIFICATION OF THE RIGID VINYL MODELING TECHNIQUE: THE SL-7 STRUCTURE (SL-7-6)
The direct comparisons of a rigid vinyl structural model with its steel counterpart under equivalent load conditions has been a prerequisite to the final verification of the rigid vinyl modeling technique. Such a program was completed and the resulting correlation described herein indicates that the structural response of a rigid vinyl model can be used to predict prototype characteristics effectively. (Author)

Rodd, JL
Ship Structure Committee Spec Rpt. SSC-259, Apr. 1976, 47 pp

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AD-A025717/0GA

148192
A SURVEY OF FASTENING TECHNIQUES FOR SHIPBUILDING
This report is aimed at defining fastening processes and techniques that are not widely used in ship construction today in terms of their applicability and potential for improving cost, construction, reliability, and maintenance of hull structures and attachments. The study includes similar and dissimilar metal-to-metal and metal-to-nonmetal joints, a generic fastener matrix of typical fasteners, fastener installation equipment and processes, proposed applications of explosion-bonded materials, and cost comparisons of various fabrication techniques. Fusion welding, diffusion bonding, friction welding, and adhesive bonding are discussed. Several fastener standards and vendor proprietary fasteners are included as figures. Extractions from Boeing Design Manual sections on mechanical fastening and adhesive bonding are included as reference attachments. Fastening systems and techniques that merit further study or verification are identified.
Sponsored by Naval Sea Systems Command.

Yutani, N Reynolds, TL
Boeing Commerical Airplane Company, (SR-207) Tech Rpt. SSC-260, 1976, 115 pp, 16 Ref.

Contract N00024-73-C-5077

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AD-A031501

148277
STATIC STRUCTURAL CALIBRATION OF SHIP RESPONSE INSTRUMENTATION SYSTEM ABOARD THE SEA-LAND MCLEAN (SL-7-7)
This document reports the results of the calibration of the strain gage portion of the ship response instrumentation installed on the SEA-LAND McLean SL-7 class containership. The calibration consisted of a succession of loading conditions achieved by selectively removing container cargo, and was performed on April 9-10, 1973 in Rotterdam. The measured stress changes are compared with calculated predictions, and the results are discussed. In general, the measurements and calculations agree substantially within tolerances assignable to physical conditions.

Boentgen, RR Wheaton, JW (Teledyne Materials Research Company)
Naval Ship Engineering Center, (SR-211) Tech. Rpt. SSC-263, 1976, 67 pp, 2 Ref.

Contract N00024-75-C-4354

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AD-A031527/5ST

148278
COMPUTER PROGRAMS FOR THE DIGITIZING AND USING OF LIBRARY TAPES OF SHIP STRESS AND ENVIRONMENT DATA
Details of computer prog[illegible]heir operating instructions are given for the processing of logbo[illegible]nd associated analogue stress signals into digital format. Th[illegible]eypunched, edited and formatted for subsequent mergin[illegible]ignal which has been processed through an Analogue-to[illegible]nverter. Accumulation of summary data during the proc[illegible]utput onto digital magnetic tape which is then available for u[illegible]al analyses. A program for retrieval of selected data from the digital magnetic tape is included.

Johnson, AE, Jr Flaherty, JA Walters, IJ
Teledyne Materials Research Company, (E-1149(d)) Final Rpt SSC-237, Feb. 1973, 106 pp, 1 Ref.

Contract N00024-69-C-5161

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148279
PREVENTING DELAYED CRACKS IN SHIP WELDS (PART I)
Delayed cracking is a continuing problem in ship steel weldments. However, with proper precautions, this type of cracking can be prevented. This document presents, in a simplified and condensed form, the causes of delayed cracking and the necessary preventive procedures. It is intended that this document will be used by shipyard personnel that do not have a technical background. Thus, detailed technical explanations are avoided.

Mishler, HW
Battelle Columbus Laboratories SSC-261, 1976, 11 pp

Contract N00024-72-C-5326

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AD-A031515/0ST

148280
PREVENTING DELAYED CRACKS IN SHIP WELDS (PART II)
This report discusses the causes of delayed cracking in ship steel welds and presents the steps necessary to prevent delayed cracking. Three factors, acting together, are responsible for the formation of delayed cracks: hydrogen dissolved in the weld, a hard microstructure in the weld or heat-affected zone, and high stresses in the weld joint. Each step that is taken to prevent delayed cracks has the purpose of eliminating or significantly reducing at least one of these factors.

Mishler, HW
Battelle Columbus Laboratories, (SR-210) SSC-262, 1976, 62 pp, 23 Ref.

Contract N00024-72-C-5326

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148317
FIRST SEASON RESULTS FROM SHIP RESPONSE INSTRUMENTATION ABOARD THE SL-7 CLASS CONTAINERSHIP S.S. SEA-LAND MCLEAN IN NORTH ATLANTIC SERVICE (SL-7-8)
This report contains data, with appropriate evaluation and discussions, collected during the first season on board the S.S. SEA-LAND McLEAN. Data collection began with westbound Voyage 1 on October 8, 1972 and terminated with the eastbound passage of Voyage 12 on April 5, 1973. A total of 80 data tapes were recorded containing in excess of 50,000 separate data intervals from more than 100 transducers. Discussions include a description of the digitized data, comparisons of stresses with sea state, simultaneous response data from all transducers during selected portions of a rough voyage, and a consideration of torsional responses.

Boentgen, RR Fain, RA Wheaton, JW (Teledyne Materials Research Company)
Ship Structure Committee Tech. Rpt. SSC-264, Sept. 1976, 182 pp

Contract N00024-73-C-5059

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AD-A039752/1ST

151689
THIRD SEASON RESULTS FROM SHIP RESPONSE INSTRUMENTATION ABOARD THE SL-7 CLASS CONTAINERSHIP S.S. SEA-LAND MCLEAN IN NORTH ATLANTIC SERVICE (SL-7-10)
One of the class of eight SL-7 high speed containerships has been extensively instrumented with stress, strain and motion sensors. These have been modified for the Third Season of data acquisition to emphasize measurement of hatch corner and bow sideshell strains. Much of the previous instrumentation inventory, including a wave height radar and Tucker wave meter, has also been employed in the Third Season. This report contains a summary of the recorded data, examples of the analog records, a catalog of the data formats and a listing of the available data intervals. Some analysis of the data is also reported including midship bending stresses encompassing all three data seasons. Data collection for the third season began with the west-bound North Atlantic voyage 59 on January 17, 1975 and terminated with westbound voyage 61 on March 17, 1975. (Author)

Boentgen, RR

Teledyne Materials Research Company, (F43422) Tech. Rpt. SSC-SL-7-10, Dec. 1975, 174 pp

Contract N00024-75-C-4354

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AD-A034175/0ST

151661
SECOND SEASON RESULTS FROM SHIP RESPONSE INSTRUMENTATION ABOARD SL-7 CLASS CONTAINERSHIP S.S. SEA-LAND MCLEAN IN NORTH ATLANTIC SERVICE (SL-7-9)

This report contains data, with appropriate evaluation and discussions, collected during the second season (October 1973-March 1974) aboard the S.S. SEA-LAND McLEAN. The instrumentation system generated more than 60,000 half-hour intervals of analog data from over 100 transducers. Parametric studies of longitudinal, horizontal, and torsional stress are presented, and the response of the ship to a severe storm is discussed in detail. (Author)

Boentgen, RR Wheaton, JW
Teledyne Materials Research Company Tech. Rpt. SSC- SL-7-9, Oct. 1975, 151 pp

Contract N00024-74-C-5163

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AD-A034162/8ST

157298
GUIDE FOR INTERPRETATION OF NONDESTRUCTIVE TESTS OF ORDINARY-, MEDIUM-, AND HIGH-STRENGTH, LOW-ALLOY STEEL BUTT-JOINT WELDMENTS IN SHIP HULL STRUCTURES

A survey was made of various codes and standards applicable to the interpretation of nondestructive tests of welds in ordinary-, medium-, and high-strength low-alloy steels. This guide has been developed for application to steel welds in ship hull structures of the general cargo, tanker and passenger class as differentiated from naval ships. The guide exhibits nondestructive test results of several classes of defects with suitable test to delineate the maximum size and/or distribution that would be recommended as acceptable for ship hulls.

Ship Structure Committee, Natl Academy of Sciences Final Rpt. SSC-245, Apr. 1977, 48 pp

Contract N00024-69-005225

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157300
A STUDY OF SHIP HULL CRACK ARRESTER SYSTEMS

A world-wide survey of marine engineers, shipyards, and regulating agencies was conducted to ascertain both current and contemplated approaches to arresting cracks in ship hulls. As a result of this survey, a crack arrester classification system was developed. The classification was used to aid in a systematic investigation aimed at determining the most attractive practical schemes for arresting cracks in ship hulls. In addition to describing the classification system, example calculations showing quantitatively the effect of imposing various kinds of mechanical arrester devices in the path of a fast-moving crack.

Kanninen, M Mills, E Hahn, GT Marschall, C Broek, D Coyle, A Masubuchi, K Itoga, K (Massachusetts Institute of Technology)
Battelle Memorial Institute Final Rpt. SSC-265, Dec. 1976, 98 pp

Contract N00024-75-C-4325

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164216
RESULTS FROM FULL-SCALE MEASUREMENTS OF MIDSHIP BENDING STRESSES ON TWO DRY-CARGO SHIPS REPORT #2

Tabulated stress data from unattended instrumentation systems are presented for two ships covering a total of 6,528 hours of being at sea. One ship has her machinery amidship, while the other has hers aft. The data indicate that the trend of maximum peak-to-peak stress vs. sea state for the two ships is similar. The maximum peak-to-peak stress recorded in this data is approximately 6900 psi for a sea state 11.

Fritch, DJ Bailey, FC Wheaton, JW
Teledyne Materials Research Company SSC-181, Mar. 1967, 23 pp, 12 Fig., 1 Tab., 4 Ref., 1 App.

Contract NObs-88349

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AD 650239

164217
PROGRAM TRANSHIP-A COMPUTER PROGRAM FOR THE DESIGN OF THE MIDSHIP SECTION OF A TRANSVERSELY-FRAMED DRY CARGO SHIP, PART II

This report presents the computer program corresponding to the method of design expounded in the Ship Structure Committee Report SSC-215, "A Guide for the Synthesis of Ship Structures--Part One--The Midship Hold of a Transversely-Framed, Dry Cargo Ship." The program consists in an executive routine, called TRANSHIP, and twenty seven subroutines.

Sponsored by the Naval Ship Engineering Center, (Ship Structure Committee Research Project SR-175).

St. Denis, M
National Engineering Science Company, (Project No. SR-175) SSC-216, Dec. 1971, 144 pp

Contract N00024-68-C-5403

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AD 753531

164218
NOTCH BRITTLENESS AFTER FRACTURE

Notched plates and bars prestrained in compression or extension, before or after notching, at 70 deg F or 550 deg F were tested to fracture in tension at-16 deg F. It was found that a catastrophic reduction of ductility could be caused by small prestrains. Uniform longitudinal or transverse prestraining by as little as 0.05 at 70 deg F reduced the initial ductility of notched bars by a factor of 4 or more. Hot prestraining was even more damaging: the greatest drop in the ductility at-16 deg F was caused by prestrains of only 0.025 at 550 deg F. These tests indicate that the "brittle" behavior of mild steel structures results from some damaging prior history of straining. Therefore, the proper selection of steels should be based on their resistance to embrittlement by suitable straining rather than on their properties in the initial undamaged state. The presented testing methods offer a great control over the steel ductility. They would be useful both in steel assessment and in the investigations of the factors influencing the resistance of steel to fracture.

Sponsored by the Naval Sea Systems Command, Washington, D.C. 20362. (A Ship Structure Committee Project.)

Mylonas, C Kobayashi, S
Brown University, (Project No. SR-158) Final Rpt. SSC-192, Dec. 1968, 40 pp, 25 Ref.

Contract NObs-88294

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AD 681051

164219
PLASTIC FLOW IN THE LOCALE ON NOTCHES AND CRACKS IN FE-3SI STEEL UNDER CONDITIONS APPROACHING PLANE STRAIN

The development of the plastic zones generated by sharp through-cracks and blunter notches was studied systematically in plates of Fe-3Si steel. A sensitive etching technique revealed the plastic zone both on the plate surface

and on parallel and normal interior sections. In addition, the progress of through-the-thickness deformation was followed by monitoring normal displacements at the plate surface. The work encompasses applied stress-crack length-thickness combinations in the range 0.2 is less than the absolute value of (K/Y) squared times 1/t is less than 2 (K is the stress intensity parameter, Y is the yield stress, and t is the plate thickness), with special emphasis on situations where the plastic zone is small relative to the plate thickness and a plane strain state is approached. Three kinds of relaxations are revealed: one in the plane of the plate and two accommodating through-the-thickness deformation. The latter become the dominant mode when the absolute value of (K/Y) squared time 1/t is more than 1.7 or rho is more than t/2 (rho is the zone length). Comparisons with available theoretical treatments show that the calculations of Bilby and Swinden, Tuba, and Rice and Rosengren are in accord with measured zone lengths, but none of the treatments examined provides a satisfactory description of the zone shape. The experiments also provide insights to the level of strain within the zone, and suggest that the absolute value of K/Y, 1/t equals 1 or rho equals t/4 may be a useful upper bound for the plane strain regime.

Hahn, GT Rosenfield, AR
Battelle Memorial Institute, (Project No. SR-164) SSC-191, Nov. 1968, 53 pp. 33 Ref.

Contract NObs-92383

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AD 680123

164220
THE EFFECT OF SHIP STIFFNESS UPON THE STRUCTURAL RESPONSE OF A CARGO SHIP TO AN IMPULSIVE LOAD

The purpose of the study was to set up a computer program to investigate the dynamic effects resulting from an impulsive loading on a ship and to determine how these effects tend to vary with the stiffness of the hull girder. The hull is treated as a Timoshenko beam and the solution is obtained by finite difference technique. Two codes are written: an explicit one, which is more efficient for short durations, and an explicit one, which is superior for long durations of impulse. Application is made to a dry cargo ship. Limited analysis of her response to a unit impulse indicates that, in general, reduced hull rigidity tends to be beneficial.

Sponsored by the Naval Sea Systems Command, Washington, D.C. 20362.

St. Denis, M Fersht, S
National Engineering Science Company, (Project No. SR-173) Res & Dev SSC-186, Sept. 1968, 120 pp, 19 Ref.

Contract NObs-94321

ORDER FROM: NTIS

AD 675639

164221
EXPERIMENTAL DETERMINATION OF PLASTIC CONSTRAINT AHEAD OF A SHARP CRACK UNDER PLANE-STRAIN CONDITIONS

An experimental method of identifying the plastic constraint ahead of a sharp crack loaded under plane-strain conditions is proposed. The method is based on the idea that the cleavage stress--which can be measured with unnotched bars--is the peak stress developed ahead of a crack just prior to crack extension. Ways of calculating the strain, strain rate, and yield stress appropriate for the plastic region just ahead of the crack are developed. The ratio of the cleavage stress to the local yield stress identifies the plastic constraint factor at the stress level corresponding to crack extension. Experimental results recently reported by Krafft are shown to be consistent with this interpretation. With these data, the following expression for p.c.f., the plastic constraint factor, is deduced: p.c.f. = 12 K/Y, where Y is the yield stress, K the stress intensity parameter, and the numerical constant, 2, has the dimensions inches-1/2. This result offers a way of formulating K sub Ic, the fracture toughness for crack extension by cleavage, in more basic terms and sheds some light on the metallurgical origins of K sub Ic.

Hahn, GT Rosenfield, AR
Ship Structure Committee, (Project No. SR-164) SSC-180, May 1966, 12 pp, 19 Ref.

Contract NObs-92383

ORDER FROM: NTIS

AD 646034

164222
RESIDUAL STRAINS AND DISPLACEMENTS WITHIN THE PLASTIC ZONE AHEAD OF A CRACK

Strains and displacements in the plastically yielded region generated ahead of a machined notch and a crack were detected with an interferometric technique. The measurements were performed on Fe-3Si steel sheets after unloading and reflect local yielding under plane stress conditions. The results show that notch acuity within the limits examined has little effect on the strain distribution. Measured displacements are qualitatively in accord with the theoretical expectations of the DM (Dugdale-Muskhelishvilli) model. Quantitative agreement is not obtained and this is attributed to work hardening and the Bauschinger effect, complications that are neglected in the calculation. The work also draws attention to a parameter--the width of the plastic zone at half maximum strain--useful for connecting displacement with maximum strain.

Sponsored by the Naval Sea Systems Command, Washington, D.C. 20362.

Cammett, J Rosenfield, AR Hahn, GT
Ship Structure Committee Prog Rpt. SSC-179, Nov. 1966, 16 pp, 7 Ref.

Contract NObs-92383

ORDER FROM: NTIS

AD 644815

164223
A SURVEY ON SOME RECENT BRITISH WORK ON THE BEHAVIOUR OF WARSHIP STRUCTURES

Entirely rational elastic or plastic design procedures for surface ship structures have not been achieved. During the past 15 years, considerable advances and development both in the understanding of the mechanics of ship structures and in the application of digital computers to ship problems have been made. This is a report on research in progress to obtain information on loadings at sea, with regard to both extreme and repeated cyclic loading.

Clarkson, J
Ship Structure Committee Spec Rpt. SSC-178, Nov. 1966, 25 Ref.

ORDER FROM: NTIS

AD 644738

164224
MECHANICAL PROPERTIES OF A HIGH-MANGANESE, LOW-CARBON STEEL FOR WELDED HEAVY-SECTION SHIP PLATE

The need for a steel of suitable strength, weldability, and resistance to brittle fracture for use in heavy-sections in ships of large tonnage prompted the Ship Structure Committee to support a project designed to lay the basis for the selection of a suitable steel. The initial phase of the program was intended to establish suitable testing methods for measuring the resistance of heavy-section steel plates to brittle fracture, and to provide data on the degree to which the level of toughness performance of the steel must be raised to counteract size effects as plate thickness is increased. The second phase of the program, covered by the present report, has been a study of the mechanical properties and weldability of a steel composition which was judged to show promise as a steel for heavy-section ship plate. The steel was chosen on the premise that a simple carbon-manganese steel could be heat-treated to furnish the desired properties including weldability at a lower cost than that of more complex alloy steel grades. Broadly, the steel in thicknesses up to 3 inches was expected to possess the strength, resistance to brittle fracture, and weldability equal to 2-inch normalized ABS Class C steel. While the laboratory tests could not be used to determine the service properties of the steel, they provided a direct comparison of the steel to ABS Class C, whose characteristics and service performance are well-known.

Sponsored by the Naval Sea Systems Command, Washington, D.C. 20362.

Stout, RD Roper, CR
Ship Structure Committee Prog. Rept SSC-175, Apr. 1966, 26 pp, 1 Ref.

Contract NObs-93188

ORDER FROM: NTIS

AD 637211

164225

INVESTIGATION OF RESIDUAL STRESSES IN STEEL WELDMENTS

Experimental hydrogen-induced-cracking tests were made on 45 weldments in mild steel, HY-80 steel, a commercial high-strength structural steel, and SAE 4340 steel. Extensive cracks were found in weldments made in SAE 4340 steel (oil quenched and tempered at 500 F) after hydrogen charging for relatively short times. Systematic crack patterns that could be related to residual stress distributions were obtained on various complex weldments. When steels of lower strengths were used, longer charging time was required to produce cracks, and crack patterns were less pronounced. The hydrogen-induced-cracking technique does not seem to work on mid-steel weldments. It has been found that hydrogen-induced cracking is stress sensitive rather than plastic-strain sensitive. This has been proved by hydrogen-induced-cracking tests on mechanically stress-relieved specimens and press-fit specimens in which residual stresses were produced by purely elastic deformation. It was found that distributions of residual stresses in mild-steel and SAE 4340 steel weldments were quite similar despite the considerable differences in the yield strengths of the two base plates and the weld metals. This was proved in butt joints up to 38 inches long and complex welded structures.

Sponsored by the Naval Sea Systems Command, Washington, D.C. 20362.

Masubuchi, K Martin, DC
Ship Structure Committee Final Rpt. SSC-174, Sept. 1966, 103 pp, 26 Ref.

Contract NObs-92521

ORDER FROM: NTIS

AD 639619

164226

EXHAUSTION OF DUCTILITY UNDER NOTCH CONSTRAINT FOLLOWING UNIFORM PRESTRAINING

Earlier studies of reduction of ductility by prestraining have been extended to include behavior under severe notch constraint of uniformly prestrained and aged ABS-B and Project E-Steel. Tension bars with deep circumferential grooves of 20 deg angle and 0.030 or 0.010 or 0.003 in. notch radius were used. The depth of the grooves was sufficient to enable the more ductile bars to reach and exceed the theoretical flow limit for infinite depth based on the 0.1% offset yield stress sigma sub 0.1. Both load and elongation at the groove shoulders were measured. The average fracture stress increased with increasing prestrain at first at both the same rate as the sigma sub 0.1 stress and the corresponding flow limit and then at a slower rate, so that at a prestrain of 0.20 it was clearly below the corresponding flow limit. From there on the fracture stress gradually decreased till at 0.60 prestrain it was close to the 0.1% offset yield stress of unnotched bars. According to the criterion of average fracture stress, the transition from ductile to brittle behavior under the conditions at the notch was very gradual and occurred at prestrains close to 0.20. On the contrary the elongation at the shoulders, which is a direct measure of ductility, showed an abrupt drop at prestrains as low as 0.05, which is a tremendous reduction from the prestrain of 0.75 needed to embrittle smooth bars of ABS-B steel subjected to tension, and of 0.48 when subjected to bending. The conditions of fracture at a notch in a strain hardening material are discussed in relation with the obtained results.

Sponsored by the Naval Sea Systems Command, Washington, D.C. 20362.

Mylonas, C
Ship Structure Committee Tech Rpt. SSC-173, Nov. 1965, 40 pp, 14 Ref.

Contract NObs-88294

ORDER FROM: NTIS

AD 637143

164227

CRACK EXTENSION AND PROPAGATION UNDER PLANE STRESS

Experiments are described that reveal the three-dimensional character of the plastic zone in front of notches and cracks in plates of an Fe-3Si steel and a plain carbon steel. These define the plane-stress regime as a function of applied stress and plate thickness. They also provide a rationale for the DM (Dugdale-Muskhelishvili) model as a tentative elastic-plastic solution of a crack under plane stress. Refinements that offer a way of taking work hardening and rate-sensitive plastic deformation into account are described. In this way, unnotched tensile properties--the stress-strain curve and reduction in area--are used to calculate plastic-zone size, crack-tip displacements and strains, the crack-extension stress, and the fracture toughness, in accord with experiments. Finally, the approach is extended to ductile crack propagation and used to calculate the crack speed and the stress, strain, and strain rates imposed on material in advance of a moving crack.

Sponsored by the Naval Sea Systems Command, Washington, D.C. 20362.

Rosenfield, AR Dai, PK Hahn, GT
Ship Structure Committee SSC-172, Mar. 1966, 38 pp, 34 Ref.

Contract NObs-92383

ORDER FROM: NTIS

AD 480619

165435

ENVIRONMENTAL WAVE DATA FOR DETERMINING HULL STRUCTURAL LOADINGS

A survey evaluation is given of observed and measured wave data covering major U.S. routes, with appendices, tabulations and maps. The introduction of theoretical formulations leads to the discussion and evaluation of wave spectral hindcasting techniques. The methods used to predict ship motions and loads are explained followed by a section discussing the wave data format required for predicting short and long-term loads and motions as well as numerical examples showing the effect on and sensitivity of predictions to variation in wave data format. Based on the preceding discussion, presently available data suggested for use in determining ship loads are given. The use of a combination of statistics based on observations on the frequency of occurrence of various wave heights and a spectral family of measured spectra grouped by wave height is recommended. Finally, a survey of current and planned data collection projects is given.

Hoffman, D Walden, DA
Webb Institute of Naval Architecture Final Rpt. SSC-268, June 1976, 222 pp, Refs.

Contract N00024-75-C-4209

ORDER FROM: NTIS

AD A047116

166031

REVIEW OF SHIP STRUCTURAL DETAILS

This review of structural detail design is intended to serve as a summary of the state of the art and a guide to development of tools for design and analysis of these details. It includes a count of common structural details aboard two modern commercial vessels, and labor estimates for representative sizes of those details intended to provide a total cost per type of detail ranking for those ships. Current shipyard practice is reported with sketches and application description of about 160 ship structural details. Design improvements related to shipyard producibility are suggested. The most relevant rules promulgated by technical and classification societies are excerpted, and comparison of rules is illustrated by application to specific examples. Damage induced by poor design or fabrication of details is reviewed and illustrated. The relatively sparse technical literature related to analysis and design of structural details is summarized. A framework for fatigue criteria is developed as a suggestion for possible detail strength criteria.

Glasfeld, R Jordan, D Kerr, MJ Zoller, D
General Dynamics Corporation Final Rpt. SSC-266, 1977, 327 pp

Contract N00024-74-C-5230

ORDER FROM: NTIS, United States Coast Guard

AD-A040941/7ST

167720
COMPRESSIVE STRENGTH OF SHIP HULL GIRDERS--PART III--THEORY AND ADDITIONAL EXPERIMENTS

A phenomenological theory has been developed for predicting the ultimate strength of rectangular structural plates loaded in uniaxial longitudinal compression, uniaxial transverse compression and biaxial compression. The effects of normal pressure also were considered. The theory was found to be in reasonable agreement with experimental data. Certain areas of the theory and some of the experiments require additional study. The longitudinal compression theory was found to agree well with corresponding theories of other investigators. However, the new theory employs the detailed stress-strain curve for a given material, which the others do not, and demonstrates that, in general, strength prediction requires a curve for each structural material. The commonly used parameter, (b/t)(sigma sub cy/E) to the 1/2 power, is shown not to be universally employable across the total material spectrum as the factor identifying ultimate strength. Other results of broad interest are the demonstration of the applicability of a biaxial plasticity law to biaxial strength theory and the delineation of a method for selecting an optimum material for compression strength. The use of stress-strain curves for strain analysis of critical and ultimate strengths is described. They were employed to construct theoretical strength curves. Theoretical relations and corresponding curves have been developed for perfect plates. The effects of strength degrading factors are discussed and the analysis of residual stress effects is included.

Becker, H Colao, A
Naval Ship Engineering Center Final Rpt. SSC-267, Apr. 1977, 66 pp, 25 Ref.

Contract N00024-72-C-5565

ORDER FROM: NTIS

AD-A047115

167738
STRUCTURAL TESTS OF SL-7 SHIP MODEL (SL-7-11)

A steel structural 1:50 model test program has been conducted for the 942-ft., 33-knots, SL-7 Containership. This report describes development of the model, through the test program and then to the test results. The principal stresses measured were longitudinal normal stresses and shear stresses. The model was loaded by means of calibrated steel weights and precision pulleys. The vertical and lateral bending responses corresponded closely to elementary beam theory; the vertical shear amidships pattern appeared to have the correct shape for the known boundary conditions at the keel and deck edges; and the torsional responses indicated that the bow and stern sections and machinery box offered considerable warping restraint. A finite element analysis of the model and ship midship sections indicated that nearly the same torsional response was observed for each.

Webster, WC Payer, HG
California University, Berkeley SSC-269, 1977, 248 pp

ORDER FROM: NTIS

AD-A047117

170518
GROSS PANEL STRENGTH UNDER COMBINED LOADING

The existing methods of predicting the behavior and ultimate strength of ship gross panels were evaluated, examined and in some instances, further developed. The assumptions, approximations, and deficiencies in each method were identified with the objective of determining the range of validity of each. The methods were classified in five broad categoreis with respect to their theoretical bases. Comparisons and correlations were conducted between the results of the different methods when applied to identical gross panels under biaxial edge compression and lateral pressure. Based on the identification of the assumptions and approximations in each method, and on the conducted comparisons and correlations, some expressions and procedures were selected, discussed, and extended. Lack of adequate procedures in certain areas were pointed out particularly when the collapse loads and mechanisms involve coupling between several modes of failure, and a biaxial loading condition exists in combination with lateral pressure. In some instances no clear measure of the relative reliability of the different procedures can be ascertained and a firm evidence of the "exact" solution is not available. A two-phase test program was recommended with immediate objectives and final goals outlined. An extensive bibliography is appended to this report.

Mansour, AE
Mansour Engineering Incorporated Final Rpt. SSC-270, Dec. 1977, 72 pp, 70 Ref.

Contract N00024-75-C-4015

ORDER FROM:

AD-A049337/9ST

178693
IN-SERVICE PERFORMANCE OF STRUCTURAL DETAILS

This report includes the results of a structural detail survey of twelve families of approximately fifty different ships. Seven ship types were surveyed to determine whether or not predicted failures actually occurred. The families are beam brackets, tripping brackets, non-tight collars, tight collars, gunwale connections, knife edge crossings, miscellaneous cutouts, clearance cuts, deck cutouts, stanchion ends, stiffner ends, and panel stiffeners. Fifty-six groups evolved with a total of 553 observed variations in structural configuration. The data are synthesized by family groups. During the survey 490,210 details with 3,307 failures were observed. Eighty-two percent of the failures were in the cargo space and were predominately located in structure adjacent to the side shell. The remaining 18% were distributed, 10% forward and 8% aft of the cargo spaces. Feedback data of this type should be invaluable to design and repair offices. It depicts, with sketches and photographs, the variations of structural configurations and tabulates all of the data collected during the survey. As an aid to engineers and designers, failure causes such as design, fabrication, maintenance and operation are postulated. Systematic performance studies of this type should be conducted in all areas of ship construction.

This document was sponsored by the Naval Sea Systems Command. It is a Final Technical Report on Project SR-1232, "Structural Details Failure Survey".

Jordan, CR Cochran, CS
Newport News Shipbuilding Final Rpt. SSC-272, Mar. 1978, 201 p., 16 Ref.

N00024-76-C-4362

ORDER FROM: NTIS

AD-A057212/3ST

178694
SURVEY OF STRUCTURAL TOLERANCES IN THE UNITED STATES COMMERCIAL SHIPBUILDING INDUSTRY

Deviations from ideal structural design of different types of vessels during construction and service are investigated. Selected U.S. commercial shipyards, ship owner/operators, steel mills, and foreign classification societies are surveyed or interviewed with the purpose of documenting major deviations and recurring structural imperfections, and determining the factors leading to these deviations. An effort is also made to determine the extent of deviations from theoretical design and to establish, wherever possible, structural tolerance limits which are most commonly used in U.S. yards and which can therefore be considered representative of U.S. shipbuilding practice. These are compared to published international structural tolerance standards, and recommendations are given for further study.

This document was sponsored by the Naval Ship Engineering Center. It is a Final Report on Project SR-1233 "Structural Tolerance Survey".

Basar, NS Stanley, RF
Rosenblatt (M) and Son, Incorporated SSC-273, Apr. 1978, 215 p.

Contract N00024-76-C-4059

ORDER FROM: NTIS

AD-A057597/7ST

178997
A CORRELATION STUDY OF SL-7 CONTAINERSHIP LOADS AND MOTIONS--MODEL TESTS AND COMPUTER SIMULATION (SL-7-12)

A correlation study is carried out for the SL-7 container ship by means of comparison of results for structural loads and motions in waves obtained

from model tests and computer calculations. The different aspects that could affect computer predictions are examined via further computations and analyses in order to determine their influence on the output data. Similarly an examination of the possible effects that influence the model test data are also examined. The main objective of this study is to determine the capabilities of both test methods for prediction purposes. Comparisons are also made between theoretical predictions and results for other related ship models for which test data are available.

Kaplan, P (Oceanics, Incorporated); Sargent, TP Silbert, M
Ship Structure Committee SSC-271, 1977, 89 pp

ORDER FROM: NTIS

AD-A049349/4ST

179707

FRACTURE BEHAVIOR CHARACTERIZATION OF SHIP STEELS AND WELDMENTS

In order to enlarge upon current understanding of the behavior of ship steels and weldments, a series of mechanical tests were performed on seven grades of ship steel. These steels were ABS-B, CS, AH-32, EH-32, ASTM A517-D, A678-C, and A537-B and covered the range of ordinary as-rolled, to high strength quenched and tempered alloys. In addition, all materials but the EH-32 were utilized to produce welded plates. These weldments, either manual shielded metal arc or submerged arc procedure, were then machined into test specimens. The test program was designed to probe a large number of specimen and material parameters. The mechanical tests performed were the static tension test, the Charpy impact test, weld side bend test, dynamic tear test, and the drop weight-nil ductility temperature test. Two structural tests were designed to exercise the crack initiation and arrest capability of the steels. One of these tests was the standard explosion crack starter test while the other was a variation of the explosion tear test. The results indicated the general superiority of the fracture performance of the high strength, quenched and tempered alloys over the ordinary ship steels. The structural tests demonstrated the superiority of the manual metal arc welding procedure. This result was generally confirmed by the results of the dynamic tear tests. The data were compared to the proposed fracture criterion proposed by Rolfe, et. al., as presented in SSC-244. Only one material, EH-32, passed all tests prescribed by the proposed criterion.

Francis, PH Cook, TS Nagy, A
Southwest Research Institute Final Rpt. SSC-276, May 1978, 96 p.

Contract N00024-75-C-4058

ORDER FROM: NTIS

AD-A058939/0ST

179817

DEVELOPMENT OF AN INSTRUMENTATION PACKAGE TO RECORD FULL-SCALE SHIP SLAM DATA

An instrumentation set has been developed for use in investigating the slamming experience of a full-scale ship. Methods for treating both bow-flare and bottom slamming have been considered. A radar altimeter was used to sense the relative height of the wave at the transducer location in order to determine the relative velocity between the bottom or the bow of the ship and the wave at the instant of slam.

Performed for the Ship Structure Committee; Final Report on Project SR-1235, "Full-Scale Ship Slam Investigation."

Band, EGU Euler, AJ
Payne, Incorporated Final Rpt. SSC-274, July 1978, 112 p.

Contract N00024-76-C-4399

ORDER FROM: NTIS

AD-A059549/6ST

182526

BIBLIOGRAPHY FOR THE STUDY OF PROPELLER-INDUCED VIBRATION IN HULL STRUCTURAL ELEMENTS

This bibliography was prepared as part of the effort on Ship Structure Committee Project SR-240, "Propeller-Induced Vibration in Hull Structural Elements." It is published separately from the final report because it can serve as a ready reference to investigators in the field. This document is not meant to be an exhaustive bibliography of all references dealing with propeller-induced vibrations. Emphasis has been placed on the current generation of large, high-powered ships.

Burnside, OH Kana, DD (Southwest Research Institute); Reed, FE (Littleton Research & Engineering Corporation)
Southwest Research Institute SSC-281, SWRI-02-4821, July 1978, 65 pp

Contract CG-61907-A

ORDER FROM: NTIS

AD-A062996/4ST

183173

WAVEMETER DATA REDUCTION METHOD AND INITIAL DATA FOR THE SL-7 CONTAINERSHIP (SL-7-15)

So that more precise correlations between full scale observations and analytical and model results could be carried out, one of the objectives of the instrumentation program for the SL-7 class container ships was the provision of instrumental measures of the wave environment. To this end, two wave meter systems were installed on the S.S. SEA-LAND McLEAN. Raw data was collected from both systems during the second (1973-1974) and third (1974-1975) winter data collecting seasons. It was the purpose of the present work to reduce this raw data, to develop and implement such corrections as were found necessary and feasible, and to correlate and evaluate the final results from the two wave meters. In carrying out this work it was necessary to at least partly reduce several other channels of recorded data, so that, as a by-product, reduced results were also obtained for midship bending stresses, roll, pitch, and two components of acceleration on the ship's bridge. As the work progressed it became evident that the volume of documentation required would grow beyond the usual dimensions of a single technical report. For this reason the analyses, the methods, the detailed results, discussions, and conclusions are contained in a series of ten related reports. This report documents some background analyses, as well as those which were necessary to develop the needed corrections to the raw digitized data. Implementation of the results of the various analyses in a second data reduction stage is discussed.

Technical Report on Project SR-1221, Correlation and Verification of Wavemeter Data from the SL-7.

Dalzell, JF
Stevens Institute of Technology Tech Rpt. SSC-278, 1978, 68 pp, 17 Ref.

Contract N00024-74-C-5451

ORDER FROM: NTIS

AD-A062391/8ST

183363

RESULTS AND EVALUATION OF THE SL-7 CONTAINERSHIP RADAR AND TUCKER WAVEMETER DATA (SL-7-23)

So that more precise correlations between full scale observations and analytical and model results could be carried out, one of the objectives of the instrumentation program for the SL-7 class container ships was the provision of instrumental measures of the wave environment. To this end, two wave meter systems were installed on the S.S. SEA-LAND McLEAN. Raw data was collected from both systems during the second (1973-1974) and third (1974-1975) winter data collecting seasons. It was the purpose of the present work to reduce this raw data, to develop and implement such corrections as were found necessary and feasible, and to correlate and evaluate the final results from the two wave meters. In carrying out this work it was necessary to at least partly reduce several other channels of recorded data, so that, as a by-product, reduced results were also obtained for midship bending stresses, roll, pitch, and two components of acceleration of the ship's bridge. As the work progressed it became evident that the volume of documentation required would grow beyond the usual dimensions of a single technical report. For this reason the analyses, the methods, the detailed results, discussions, and conclusions are contained in a series of ten related reports. This report, contains the last phases of the work, specifically, the discussion of results, the correlation and evaluations of final results from both wave meters, the conclusions, and the recommendations.

Final Technical Report on Project SR-1221, Correlation and Verification of Wavemeter Data from the SL-7.

Dalzell, JF
Stevens Institute of Technology Final Rpt. SSC-280, 1978, 37 pp, 15 Ref.

Contract N0024-74-C-5451

ORDER FROM: NTIS

AD-A062392/6ST

183364

ORIGINAL RADAR AND STANDARD TUCKER WAVEMETER SL-7 CONTAINERSHIP DATA REDUCTION AND CORRELATION SAMPLE (SL-7-14)

So that more precise correlations between full scale observations and analytical and model results could be carried out, one of the objectives of the instrumentation program for the SL-7 class container ships was the provision of instrumental measures of the wave environment. To this end, two wave meter systems were installed on the S.S. SEA-LAND McLEAN. Raw data was collected from both systems during the second (1973-1974) and third (1974-1975) winter data collecting seasons. It was the purpose of the present work to reduce this raw data, to develop and implement such corrections as were found necessary and feasible, and to correlate and evaluate the final results from the two wave meters. In carrying out this work it was necessary to at least partly reduce several other channels of recorded data, so that, as a by-product, reduced results were also obtained for midship bending stresses, roll, pitch, and two components of acceleration on the ship's bridge. As the work progressed it became evident that the volume of documentation required would grow beyond the usual dimensions of a single technical report. For this reason the analyses, the methods, the detailed results, discussions, and conclusions are contained in a series of ten related reports. The present report is the first in the series, and involves the initial stages of the work. Specifically, this report documents the several decisions and methods thought necessary in conversion of the raw data from its original analog form to digital form, the sampling and calibration of data from the second (1973-1974) season, and a summary of initial results.

Technical Report on Project SR-1221, Correlation and Verification of Wavemeter Data from the SL-7.

Dalzell, JF

Stevens Institute of Technology Tech Rpt. SSC-277, 1978, 43 pp, 2 Ref.

Contract N00024-74-C-5451

ORDER FROM: NTIS

AD-A062394/2ST

183365

MODIFIED RADAR AND STANDARD TUCKER WAVEMETER SL-7 CONTAINERSHIP DATA (SL-7-20)

So that more precise correlations between full scale observations and analytical and model results could be carried out, one of the objectives of the instrumentation program for the SL-7 class container ships was the provision of instrumentation measures of the wave environment. To this end, two wave meter systems were installed on the S.S. SEA-LAND McLEAN. Raw data was collected from both systems during the second (1973-1974) and third (1974-1975) winter data collecting seasons. It was the purpose of the present work to reduce this raw data, to develop and implement such corrections as were found necessary and feasible, and to correlate and evaluate the final results from the two wave meters. In carrying out this work it was necessary to at least partly reduce several other channels of recorded data, so that, as a by-product, reduced results were also obtained for midship bending stresses, roll, pitch, and two components of acceleration on the ship's bridge. As the work progressed it became evident that the volume of documentation required would grow beyond the usual dimensions of a single technical report. For this reason the analyses, the methods, the detailed results, discussions, and conclusions are contained in a series of ten related reports. The present report parallels the first report in the series in that it documents the sampling and calibration of data from the third (1974-1975) recording season, and presents a summary of initial results.

Technical Report on Project SR-1221, Correlation and Verification of Wavemeter Data from the SL-7.

Dalzell, JF

Stevens Institute of Technology Tech Rpt. SSC-279, 1978, 24 pp, 11 Ref.

Contract N00024-74-C-5451

ORDER FROM: NTIS

AD-A062393/4ST

190397

EFFECT OF STRAIN RATE ON THE TOUGHNESS OF SHIP STEELS

Yield strength and fracture toughness, as measured by the dynamic tear test, were determined as a function of load rate and temperature for several ship primary structure steels in strength ranges up to 100 ksi. The materials used were ABS-B, DS, AH-32, EH-32, CS, A517-D, A678-C, and A537-B, in one or two heats each. The effect of notch geometry, i.e., fatigue precracked vis-a-vis pressed notch, was investigated in some of the tests. By fully instrumenting some of the tests, the energy to maximum load as well as the total energy to failure was determined. Based on these energies, the resistance of the materials to crack initiation and to propagation could be examined. The results indicate potentially different fracture behavior between the high and low strength alloys.

Francis, PH (Southwest Research Institute); Cook, TS Nagy, A
Ship Structure Committee SSC-275, 1978, 77 p., 14 Ref.

ORDER FROM: NTIS

AD-A059-453/1ST

193548

A REPORT ON SHIPBOARD WAVEHEIGHT RADAR SYSTEM (SL-7-13)

A microwave shipboard wave-height radar sensor for measuring ocean wave spectra, developed by the Naval Research Laboratory, was installed on the containership S.S. McLean, February, 1975. The sensor's performance, design, and analysis of data for one data run are discussed. The radar system has a 3 centimeters wavelength, 2 nanoseconds pulse width, 100 watts of peak transmitted power, 10,000 pulse per second repetition rate, 2-foot parabola antenna diameter, 7 decibel receiver noise figure, 100 pulses per second equivalent pulse processing rate, and a 1-foot resolution. Results are in reasonalbe agreement with airborne measurements. Areas for improving the system are also discussed. /Author/

Chen, D Hammond, D
Ship Structure Committee Final Rpt. SSC- SL-7-13, Apr. 1978, 80 p.

ORDER FROM: NTIS

AD-A053379/4SL

194576

A LITERATURE SURVEY ON THE COLLISION AND GROUNDING PROTECTION OF SHIPS

This report contains a literature survey on various types of ship collisions including stranding and grounding. Comments are made on several aspects of the ship collision problem and the report concludes with a suggested program of research.

Final Report on Project SR-1246 "Surveillance of Ship Collision/Stranding Research Studies."

Jones, N

Massachusetts Institute of Technology, Ship Structure Committee Final Rpt. SSC-283, Aug. 1978, 60 p., 101 Ref.

Contract DOT-CG-72063-A

ORDER FROM: NTIS

AD-A069032/1ST

194577

COMPARISON OF STRESSES CALCULATED USING THE DAISY SYSTEM TO THOSE MEASURED ON THE SL-7 CONTAINERSHIP PROGRAM (SL-7-24)

A comparison of stresses calculated using the ABS/DAISY system with those measured on board the SL-7 Containership is undertaken to verify the analytical procedures used in assessing the strength of ships in a seaway. The comparisons and evaluations are performed for four different and progressively more severe technical conditions: dockside calibration, RMS stresses in head seas, instantaneous stresses in head seas and instantaneous stresses in oblique seas. The overall comparison between calculated and measured stresses for the dockside calibration is good where thermal effects were small but inconclusive elsewhere. The comparison of RMS stresses in head seas is generally satisfactory, using both the spectrum analysis approach and the equivalent regular wave approach, and the comparison of instantaneous stresses in head seas and in oblique seas is also good for the wave conditions

considered. The results show that the existing analytical tools for predicting wave loads and structural responses are suitable to assess the overall strength of the hull-girder. All the measured and calculated hull-girder stresses are of low magnitude, and no modifications to the present hull-girder strength standard are deemed necessary.

Final Report on Project SR-1236 "SL-7 Calculations Compared With Full-Scale Measured Values."

Jan, HY Chang, KT Wojnarowski, ME
American Bureau of Shipping, Ship Structure Committee Final Rpt. SSC-282, Jan. 1979, 102 p., 13 Ref.

Contract DOT-CG-63176 A

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AD-A069031/3ST

195761
CRITICAL EVALUATION OF LOW-ENERGY SHIP COLLISION-DAMAGE THEORIES AND DESIGN METHODOLOGIES. VOLUME I: EVALUATION AND RECOMMENDATIONS

This is Volume I of a two-volume report describing the results of a Ship Structure Committee study aimed at conducting a critical evaluation of low-energy ship collision damage theories and design methodologies. Data sources on ship collision damage are identified including model experiments and full scale information obtained from ship casualty records. The assumptions made by existing theories for analyzing low energy collisions are assessed and the collision energy absorption mechanisms are ranked. A method is proposed for extending Minorsky's original high-energy analysis to the low-energy regime. Recommendations for use of existing methods and for further research are made.

Van Mater, PR, Jr Giannotti, JG Jones, N Genalis, P
Giannotti & Associates, Incorporated Tech Rpt. SSC-284, July 1978, 91 p.

Contract DOT-CG-63738-A

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AD-A070567

195762
CRITICAL EVALUATION OF LOW-ENERGY SHIP COLLISION-DAMAGE THEORIES AND DESIGN METHODOLOGIES. VOLUME II: LITERATURE SEARCH AND REVIEW

This report is Volume II of a two-volume report prepared under Ship Structure Committee Project SR-237, "Critical Evaluation of Low Energy Collision Damage Theories and Design Methodologies". The material contained herein is the result of one of the tasks of the project which called for conducting a literature search and review of documents relevant to low-energy collision damage. The various data resources used were identified; the state of the art in ship collision research was summarized; an annotated bibliography of the key documents was prepared and a list of references which are considered to be relevant to the problem was developed. Volume I contains the actual assessment of the various low-energy collision damage theories and design methodologies along with recommendations for their use and future research.

Van Mater, PR, Jr Giannotti, JG Jones, N Genalis, P
Giannotti & Associates, Incorporated Tech Rpt. SSC-285, July 1978, 38 p.

Contract DOT-CG-63738-A

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AD-A070568

197070
RESULTS OF THE FIRST FIVE "DATA YEARS" OF EXTREME STRESS SCRATCH GAUGE DATA COLLECTED ABOARD SEA-LAND'S SL-7'S (SL-7-25)

This report covers the installation of Extreme Stress Gauges mounted on each of SEA-LAND's SL-7's. Data collected from each ship over a five-year period is presented in histogram form.

Fain, RA Booth, ET
Teledyne Engineering Services, United States Coast Guard Final Rpt. SSC-286, Mar. 1979, 42 p.

Contract DOT-CG-61712-A

ORDER FROM: NTIS

AD-A072945

197071
EXAMINATION OF SERVICE AND STRESS DATA OF THREE SHIPS DEVELOPMENT OF HULL GIRDER LOAD CRITERIA

This is a follow-on project to SSC-240, "Load Criteria for Ship Structural Design", which proposed methods for the estimation and superposition of the primary loads and performed sample calculations for one conventional dry cargo ship. It involved the following bending moments: Still-water due to weight and buoyancy; Ship's own wave train; Quasi-static wave-induced, vertical and lateral combined; Dynamic loads, including slamming, whipping and springing; Thermal effects. Here the service and full-scale stress data of three larger and/or faster ships (Containership SL-7, Bulk Carrier FOTINI-L and very large Crude Carrier UNIVERSE IRELAND) are examined for the purpose of the eventual development of hull-girder criteria. The examination is limited to extreme midship bending moment loads which are related to the ultimate strength. An assessment is made of the compatibility between the service and stress data of the distinctly different study ships and the analysis methods of SSC-240 and their assumptions for cargo ship type. Considerable insight is obtained into the probable correct mathematical approximations of the loads and their interrelationships. It appears that still-water bending moments can be approached probabilistically, however, considerable additional information on experienced loading conditions must be gathered to determine the statistical distributions. Additional effort is required to determine the suitable probabilistic expression and a synthesis method for the contribution of vibration to the extreme load.

Dalzell, JF Maniar, NM Hsu, MW
Rosenblatt (M) and Son, Incorporated, Naval Ship Engineering Center, Ship Structure Committee Final Rpt. SSC-287, Apr. 1979, 180 p., 40 Ref.

Contract N00024-75-C-4324

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AD-A072910

300796
THE EFFECTS OF VARYING SHIP HULL PROPORTIONS AND HULL MATERIALS ON HULL FLEXIBLITY, BENDING AND VIBRATORY STRESSES

The effect of varying ship proportions and hull materials on hull flexibility and on the concomitant bending and vibratory stresses for an ore carrier, a tanker, containership, and a general cargo ship is evaluated. With the flexibilty of the ship's hull represented by the natural frequency of the ship associated with the two-node shape, a potentially useful relation between the flexibility and bending moment has been established. An analysis indicates that forward speed affects hydrodynamic damping and forces as well as hull flexibility, and there may exist an optimal flexibility for every ship, but there is not necessarily a limit to the flexibility.

See also Report No. SSC-249 (June 1974), AD-A008388.

Chang, PY
Hydronautics, Incorporated, Ship Structure Committee Final Rpt. SSC-288, 7715-1, Apr. 1979, 68 p., 21 Ref.

Contract DOT-CG-61906-A

ORDER FROM NTIS

AD-A075477/0

300797
SIGNIFICANCE AND CONTROL OF LAMELLAR TEARING OF STEEL PLATE IN THE SHIPBUILDING INDUSTRY

Lamellar tearing is a separation in the parent or base metal caused by through-thickness strains. These strains are usually induced by weld metal shrinkage under conditions of high restraint. This manaul provides specific recommendations for controlling lamellar tearing in the types of steels used in the construction of ships and offshore platforms. A brief description of

the characteristics and mechanism of lamellar tearing shows that for lamellar tearing to occur there must be a critical combination of material susceptibility, and welding procedures and joint design which permit the development of high through-thickness strains. Tee (T) and corner joints, used extensively in ships and offshore structures, are the two basic joint configurations most susceptible to lamellar tearing. However, the incidence of lamellar tearing has been extremely rare in shipbuilding. The problem of lamellar tearing is considerably more significant in mobile and fixed offshore drilling platforms which use thick plates in highly restrained T-and cruciform joints. The factors which contribute to and influence lamellar tearing are grouped into three categories: joint design, material selection and fabrication procedures. For each parameter recommendations are presented for reducing the risk of lamellar tearing. Inquiries made to the major ship classification societies indicate that the most successful and cost-effective method of preventing lamellar tearing is the use of steels with improved through-thickness (Z-direction) properties at susceptible connections. Methods for the post-welding detection and repair of lamellar tears are reviewed as are the test procedures developed to date for determining the susceptibility of steel plates to lamellar tearing.

Sommella, J
Gibbs and Cox, Incorporated, Ship Structure Committee Final Rpt. SSC-290, 18521 (1-146), May 1979, 70 p., Refs.

Contract DOT-CG-74355-A

ORDER FROM: NTIS

AD-A075473/9

301361
A METHOD FOR ECONOMIC TRADE OFFS OF ALTERNATE SHIP STRUCTURAL MATERIALS
A method for evaluating the desirability of any proposed material in merchant ship structure has been developed. This method compares a ship designed of the new material with a similar steel ship. Comparison includes a life-cycle cost analysis and a quantified evaluation of non-economic factors. Formalized techniques for establishing the material data bank, selecting the steel ship design, developing and optimizing the new material design, and conducting the economic and non-economic comparisons are described. A sample calculation, using 5456 aluminum in a bulk ore carrier, is included to illustrate the method.
Sponsored by the Naval Sea Systems Command.

Jordan, CR Montgomery, JB Krumpen, RP, Jr Wooley, DJ
Newport News Shipbuilding and Dry Dock Company, (Job Order 2011T) Final Rpt. SSC-289, 1979, 135 p., 26 Ref.

ORDER FROM: NTIS

AD-A075457

302278
REPORT ON SHIP VIBRATION SYMPOSIUM '78
During the intense two-day period, October 16-17, 1978, an international group of 292 participants representing shipbuilders, ship designers, ship owners, researchers, classification and governmental organizations gathered and discussed all aspects of shipboard vibration, noise and hull/machinery compatibility. The eighteen technical papers presented at Ship Vibration Symposium '78 are contained in the printed proceedings and the formal discussion and authors' closures are available as a set of two volumes from The Society of Naval Architects and Marine Engineers. The purpose of this third printed volume is to summarize key conclusions and recommendations reached at the symposium. Since the topics of "vibration and noise" are complex and not fully mastered, the reader will note a certain amount of controversy and conflicting views and recommendations outlined in the report. This situation is reflected as accurately as possible in the actual written and verbal discussion that took place at the two-day symposium. In fact, in order to ensure as complete and accurate a report as possible, the draft version of the report was distributed and reviewed by the four principal SNAME panels involved with vibration and noise namely: Panel HS-7 (Vibrations), Panel H-8 (Unsteady Propeller Hydrodynamics), Panel M-20 (Machinery Vibrations), and Panel M-27 (Machinery Noise). Thus this report also reflects the comments of these four Technical & Research panels. Finally, it should be brought to the readers attention that the three printed documents, namely: (1) the proceedings, (2) the discussion and authors' closure volume, and lastly, (3) :his summary report, collectively assess the state-of-the-art of the broad subject of "vibration and noise". The primary purpose and main objective of this report, however, is unique in that it focuses on the question "where are we now and where should we be headed"? Thus, this report is a key planning document that will serve as a basic reference for the next five to ten years.

Dillon, HS
Ship Structure Committee, (G-M/TP24) Final Rpt. SSC-292, Sept. 1979, 60 p.

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AD-A079291/1

302279
UNDERWATER NONDESTRUCTIVE TESTING OF SHIP HULL WELDS
Techniques are presented whereby nondestructive testing of hull butt welds can be accomplished underwater. Radiography, ultrasonic inspection, and magnetic particle testing are discussed including the modifications necessary for underwater applications. In all cases, trained divers are required.

Youshaw, RA Dyer, C
Naval Surface Weapons Center, Naval Ship Engineering Center Final Rpt. SSC-293, Sept. 1979, 32 p.

Contract Z70099-671375

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AD-A079445/3

302280
A DESIGN PROCEDURE FOR MINIMIZING PROPELLER-INDUCED VIBRATION IN HULL STRUCTURAL ELEMENTS
A design procedure for minimizing propeller-induced vibration in hull structural elements is recommended. This procedure begins when the ship's vibration specifications are defined and continues through the design and construction process until the vibration levels measured during sea trials are compared with the specifications. Consideration is given to the hydrodynamic excitation and structural response of the propeller-induced vibration problem, with both analytical and experimental techniques being used in the design process. The recommended procedure is presented and discussed in the form of a flow diagram with 27 separate design steps. The process also contains five evaluation milestones. At these points, the design is assessed, and, if deficiencies are found, corrective action can be taken before the design proceeds. The recommended complete procedure is presented in this report for the first time. Many of the aspects of this procedure are still being developed, in particular, the influence of propeller cavitation on hull pressures and a simple but accurate treatment of water inertia. These indefinite aspects have to be treated empirically using judgment and experimental data. The portions of the procedure which are available are illustrated in an example using a single-screw, containerized and unitized cargo ship.

Burnside, OH Kana, DD Reed, FE
Southwest Research Institute, Ship Structure Committee, (SWRI 02-4821) Final Rpt. SSC-291, Sept. 1979, 160 p., 108 Ref.

Contract DOT-CG-61907-A

ORDER FROM: NTIS

AD-A079443/8

310499
REVIEW OF FILLET WELD STRENGTH PARAMETERS FOR SHIPBUILDING
This report presents the results of a review of the current fillet weld specifications of the various classification societies and a developmental procedure for analyzing these rules by a rational method for establishing required weld size, and recommendations for further research. The results indicated large deviations among rules which relate the fillet weld size to the thickness of the base plate. The required fillet weld size by the most conservative rule may be two times that required by the most liberal rule. There appears to be a need for reviewing these rules more closely by analytical means. A computer program, named "Automatic Dynamic Incremental Nonlinear Analysis (ADINA)", was used to determine the

stress distributions in the welds of tee-joints under simple tension acting along the edges of the flange. This program could be used in determining the minimum weld sizes. A detailed explanation of the rationale of using "ADINA" program or similar FEM programs is presented in this report.

Tsai, CL Itoga, K Malliris, AP McCabe, WC Masubuchi, K
Massachusetts Institute of Technology, United States Coast Guard Final Rpt. SSC-296, Feb. 1980, 57 p.

Contract DOT-CG-71455-A

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AD-A085356/4

312194
NONDESTRUCTIVE INSPECTION OF LONGITUDINAL STIFFENER BUTT WELDS IN COMMERCIAL VESSELS

A study has been made of the butt welds which join together the sections of longitudinal stiffeners in longitudinal framed ships. From a review of Coast Guard casualty reports and a survey of major shipbuilders, it was determined that there is very little evidence of structural failure in service and, therefore, no need at this time to expand nondestructive inspection to include this type of weld joint.

Youshaw, RA
Naval Surface Weapons Center, United States Coast Guard Final Rpt. SSC-295, Feb. 1980, 6 p., 3 Ref.

Contract Z70099-6-71375

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AD-A085352/3

312220
FURTHER SURVEY OF IN-SERVICE PERFORMANCE OF STRUCTURAL DETAILS

This project is an adjunct to the Ship' Structure Committee report SSC-272. Using the same survey techniques and data analysis procedures described in that report, the midship/cargo areas of an additional twelve bulk carriers, twelve containerships, and twelve general cargo ships were surveyed under Project SR-1258. The goal of both projects is to provide design and repair personnel with structural service data and recommendations that can be used to significantly decrease the number of detail failures that occur on ships of all types. The data from both surveys are combined and summarized for ready use by design and repair offices. Structural detail failure data were collected for twelve detail families (beam brackets, tripping brackets, non-tight collars, tight collars, gunwale connections, knife edge crossings, miscellaneous cutouts, clearance cuts, deck cutouts, stanchion ends, stiffener ends, and panel stiffeners) to provide guidance in the selection of structural detail configurations. Plots of percent failures versus ship type allow an engineer/designer to establish failure trends for a specific ship type. A total of 607,584 details were observed with a total of 6,856 failures. Failures were attributed to either one or a combination of five categories-design, fabrication, welding, maintenance and operation.

Jordan, CR Knight, LT
Newport News Shipbuilding, Ship Structure Committee, (1018-M) Final Rpt. SSC-294, May 1979, 187 p.

Contract DOT-CG-75172-A

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AD-A086019/7

319903
EVALUATION OF LIQUID DYNAMIC LOADS IN SLACK LNG CARGO TANKS

This report provides an evaluation of dynamic sloshing loads in slack LNG cargo tanks. A comprehensive review of worldwide scale model sloshing data is presented. The data are reduced to a common format for the purposes of defining design load coefficients. LNG tank structural details are reviewed with emphasis placed on defining unique design features which must be considered in designing LNG tanks to withstand dynamic sloshing loads. Additional scale model laboratory experiments are conducted to supplement the available model sloshing data. Experiments are conducted in combined degrees of freedom to establish the potential for multi-degree of freedom excitation for augmenting dynamic sloshing loads. Experiments are also conducted to establish the sloshing dynamic pressure-time histories which are necessary for structural response analysis. Experiments are also conducted on representative segments of a full-scale LNG ship tank structure which is loaded with a typical full-scale dynamic sloshing pressure as predicted from the model results. Analytical studies are undertaken to provide techniques for determining wall structural response to dynamic slosh loads. Finally, design methodology is presented for membrane and semi-membrane tanks, gravity tanks, and pressure tanks whereby the design procedure sequences from comparing resonant sloshing periods to ship periods, defining the design loads, and designing the tank structures affected by dynamic slosh loads by delineated procedures which vary with tank type.

Cox, PA Bowles, EB Bass, RL
Southwest Research Institute, United States Coast Guard, (SWRI Project 02-5033) Final Rpt. SSC-297, May 1980, 183 p.

Contract DOT-CG-71374-A

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AD-91153

319904
ULTIMATE STRENGTH OF A SHIP'S HULL GIRDER IN PLASTIC AND BUCKLING MODES

Knowledge of the limiting conditions beyond which a ship's hull girder will fail to perform its function is important in assessing accurately the true margin of safety in the design of ships. Such information is essential also for developing design procedures, requirements, and rules which achieve uniform standards among vessels of different sizes and types. In this report, these limiting conditions were analyzed with the objective of determining the ultimate strength of a hull girder. The ship was considered to be subjected to a realistic loading consisting of vertical and lateral bending moments and torsional moment. Buckling and instability of the hull stiffened plates, the fully plastic yield moments, and the shakedown moments were further developed in a procedure for estimating the ultimate capacity of the hull. New interaction relations for the ultimate strength of ships subjected to combined moments were developed in this study. The fracture (fatigue and brittle) modes of failure were not included. An application to a 200,000 ton displacement tanker was carried out to show the details of the procedure and to examine the effects of various factors on the ultimate capacity of the hull. Lack of adequate formulations in certain areas were pointed out particularly when the collapse mode involved coupling between several mechanisms of failure. Analytical studies as well as a two-part test program were recommended with their objectives outlined.

Mansour, AE Thayamballi, A
Mansour Engineering Incorporated, United States Coast Guard Final Rpt. SSC-299, June 1980, 68p., 44 Ref.

Contract DOT-CG-74755-A

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AD-91154

319905
INVESTIGATION OF STEELS IMPROVED WELDABILITY IN SHIP CONSTRUCTION-PHASE I

This report covers the first phase of a three-year study to select the optimum materials and welding parameters to improve resistance to degradation of the heat-affected-zone properties in weldments made with high-deposition-rate processes. Two production steels and twenty 500-pound laboratory heats of steels of varying chemical compositions reflecting low carbon and sulfur content, silicon-aluminum deoxidation practice, globular sulfides, fine titanium nitrides, and treatments with rare earth metals, boron and calcium have been recommended for further examination.

Vanderbeck, RW
United States Steel Corporation, United States Coast Guard Intrm Rpt. SSC-298, May 1980, 26 p., 53 Ref.

Contract DOT-F-1700.7

ORDER FROM: NTIS

AD-91106

327658
RADAR AND TUCKER WAVEMETER DATA FROM SEA-LAND MCLEAN VOYAGES 35 AND 36E (SL-7-19)
For abstract see MRIS 327663.

Dalzell, JF
Stevens Institute of Technology, (F42270) Tech Rpt. SSC- SL-7-19, SIT-DL-77-1935, Aug. 1978, 153p

Contract N00024-74-C-5451

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AD-A057157/0ST

327659
RADAR AND TUCKER WAVEMETER DATA FROM SEA-LAND MCLEAN VOYAGE 34 (SL-7-18)
For abstract see MRIS 327663.

Dalzell, JF
Stevens Institute of Technology, (F42270) Tech Rpt. SSC- SL-7-18, SIT-DL-77-1934, Aug. 1978, 109p

Contract N00024-74-C-5451

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AD-A057156/2ST

327660
RADAR AND TUCKER WAVEMETER DATA FROM SEA-LAND MCLEAN VOYAGE 33 (SL-7-17)
For abstract see MRIS 327663.

Dalzell, JF
Stevens Institute of Technology, (F42270) Tech Rpt. SSC- SL-7-17, SIT-DL-77-1933, Aug. 1978, 123p

Contract N00024-74-C-5451

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AD-A057155/4ST

327661
RADAR AND TUCKER WAVEMETER DATA FROM SEA-LAND MCLEAN VOYAGE 32 (SL-7-16)
For abstract see MRIS 327663.

Dalzell, JF
Stevens Institute of Technology, (F42270) Tech Rpt. SSC- SL-7-16, SIT-DL-77-1931, Aug. 1978, 123p

Contract N00024-74-C-5451

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AD-A057154/7ST

327662
RADAR AND TUCKER WAVEMETER DATA FROM SEA-LAND MCLEAN- VOYAGE 61 (SL-7-22)
For abstract see MRIS 327663.

Dalzell, JF
Stevens Institute of Technology, (F42270) Tech Rpt. SSC- SL-7-22, SIT-DL-77-1943, Aug. 1978, 102p

Contract N00024-74-C-5451

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AD-A057005/1ST

327663
RADAR AND TUCKER WAVEMETER DATA FROM SEA-LAND MCLEAN- VOYAGE 60 (SL-7-21)
So that more precise correlations between full scale observations and analytical and model results could be carried out, one of the objectives of the instrumentation program for the SL-7 class container ships was the provision of recording the wave environment. To this end, two wave meter systems were installed on the S.S. SEA-LAND McLEAN. Raw data was collected from both systems during the second (1973-1974) and third (1974-1975) winter data collecting seasons. It was the purpose of the present work to reduce this raw data, to develop and implement such corrections as were found necessary and feasible, and to correlate and evaluate the final results from the two wave meters. In carrying out this work it was necessary to at least partly reduce several other channels of recorded data, so that, as a by-product, reduced results were also obtained for midship bending stresses, roll, pitch, and two components of acceleration on the ship's bridge.

Dalzell, JF
Stevens Institute of Technology, (F42270) Tech Rpt. SSC- SL-7-21, SIT-DL-77-1942, Aug. 1978, 96p

Contract N00024-74-C-5451

ORDER FROM: NTIS

AD-A057004/4ST

327666
REVERSED-BEND TESTS OF ABS-C STEEL WITH AS-ROLLED AND MACHINED SURFACES
Comparative tests between bars with as-rolled and with machined surfaces show a small difference in the compressive prestrain needed to exhaust the original extensional ductility of the steel, as this is determined by the reversed bend test. Machined bars show a higher exhaustion limit (prestrain) than as-rolled bars by 0.03 at 70 F and 0.06 at -16 F. Stress calculations show that the most brittle fractures may occur at applied elastic macroscopic stresses as low as about 50 ksi at 70 F and about 30 ksi at -16 F. Highly ductile bars sustained a stress close to 90 ksi at both test temperatures. (Author)

Report on Macrofracture Fundamentals. Distribution limitation now removed. NOTE: Only 35mm microfilm is available. No microfiche.

Satoh, K Mylonas, C
Brown University, (S F013 02 04) Prog Rpt. SSC-166, Apr. 1965, 24p

Contract NOBS-88294

ORDER FROM: NTIS

AD-460575/4ST

327669
A STUDY TO OBTAIN VERIFICATION OF LIQUID NATURAL GAS (LNG) TANK LOADING CRITERIA
A study of LNG tank loading criteria is presented that includes a survey and review of load criteria presently employed in the design of cargo tanks for LNG carriers. Motion and acceleration values as determined from these criteria are compared to ship motion calculations and available full-scale data. A comparison of LNG tank loads, as predicted by current classification society and regulatory agency criteria, is given along with recommended updated criteria in each of seventeen load categories. Model tests and fullscale measurement programs to provide adequate data for verification of load and acceleration criteria are also outlined. (Author)

Bass, RL Hokanson, JC Cox, PA
Southwest Research Institute, (SR-218) SSC-258, June 1975, 291p

Contract N00024-74-C-5136

ORDER FROM: NTIS

AD-A025716/2ST

327670
FURTHER ANALYSIS OF SLAMMING DATA FROM THE S. S. WOLVERINE STATE
The pressure, acceleration, and hull bending stress data from the full-scale slamming measurements on the S.S. WOLVERINE STATE were analyzed in detail to provide additional information on frequency-of-occurrence, elapsed time between slams, correlation with environmental conditions, pressure-velocity relationship, correlation with midship transient stress, and pressure-location-time distribution. Seventeen separate measurements were made on a group of 26 severe slams to provide a data base for the investigation, and data from more than 1,000 slams which occurred over approximately 49 hours of slamming during 3 different voyages were used in establishing the correlation with environmental conditions. A number of statistical correlations were examined, and pressure-velocity measurements provided additional data for comparison with model results.

Wheaton, JW

Teledyne Materials Research Company, Ship Structure Committee Final Rpt. SSC-255, 1976, 58p

Contract N00024-72-C-5047

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AD-A021338/9ST

327671
THIRD DECADE OF RESEARCH UNDER THE SHIP STRUCTURE COMMITTEE
Results of the research efforts of the Ship Structure Committee from the past decade are presented. Particular attention is given to the contributions made by this research to achieving the broad goals of the Ship Structure Committee: design methods, verifications, load criteria, materials criteria, fabrication advanced concepts, information retrieval and dissemination, and the teaching of naval architecture.

Chazal, EA Goldberg, JE Nachtsheim, JJ Rumke, RW Stavovy, AB
Ship Structure Committee SSC-252, 1976, 30p

ORDER FROM: NTIS

AD-A021290/2ST

327672
A GUIDE FOR THE NONDESTRUCTIVE TESTING OF NON-BUTT WELDS IN COMMERCIAL SHIPS. PART 1
Procedures are presented for performing visual inspection, magnetic particle testing, radiography, ultrasonics, and penetrant testing on steel welds in the thickness range of 1/2 inches to 2 1/2 inches. The basic weld joints considered are the corner joint, the Tee, 'X', and the lap joint. A discussion is presented for each of the inspection methods whereby weld quality may be controlled in a meaningful way when there is a need to do so.

Youshaw, RA Criscuolo, EL
Naval Ordnance Laboratory, (NAVSHIPS-00-0141) Final Rpt. SSC-253, NOLTR-74-138-Pt-1, Dec. 1974, 62p

ORDER FROM: NTIS

AD-A014547/4ST

327673
FRACTURE-CONTROL GUIDELINES FOR WELDED STEEL SHIP HULLS
The Report provides comprehensive toughness criteria for welded ship hulls that can be used for steels of all strength levels. Because of the fact that stress concentrations are always present in large complex welded structures and therefore high stresses as well as discontinuities or flaws will be present in welded ship hulls, primary emphasis in the proposed fracture-control guidelines is placed on the use of steels with moderate levels of notch-toughness and on the use of properly designed crack arresters. In general, concepts of fracture mechanics are used to develop the material toughness level that is required for fail-safe operation of welded ship hulls.

Rolfe, ST Rhea, DM Kuzmanovic, BO
Kansas University, Ship Structure Committee, United States Coast Guard, (SR-202) Final Rpt. SSC-244, 1974, 134p

Contract N00024-72-C-5316

ORDER FROM: NTIS

AD/A-004553/4ST

327675
A LIMITED SURVEY OF SHIP STRUCTURAL DAMAGE
A limited investigation, conducted to determine the availability of data on ship casualties involving structural damage, revealed 824 applicable cases. A method was devised for reducing reported casualty data into a format adaptable to automatic tabulation and analysis. Collision with fixed and mobile structures was found to be the predominant cause of structural damage; heavy weather damage to the forefoot and forward weather deck also occurred with significant frequency. Patterns of damage frequency and location existed on a number of classes of ships. These have been interpreted to indicate how structures could be altered to reduce the damage sustained. Recommendations are made to continue the data collection and analysis program and to investigate more extensively the ways in which significant structural design information can be extracted. (Author)

Hawkins, S Levine, GH Taggart, R
Taggart (Robert), Incorporated, (SR189) Final Rpt. SSC-220, RT-29406, 1971, 37p

Contract N00024-70-C-5214

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327676
EFFECT OF FLAME AND MECHANICAL STRAIGHTENING ON MATERIAL PROPERTIES OF WELDMENTS
An experimental study was conducted to determine the effects of mechanical straightening and flame straightening on the properties of steels used in shipbuilding. The steels investigated during this program included an ordinary carbon steel (ABS-B), two low-alloy, high-strength steels (A441 and A537), and a quenched and tempered steel (A517, Grade A). The removal of distortion in unwelded and welded test plates was accomplished by (1) mechanical straightening at room temperature, 1000F, 1300F, and (2) flame straightening in the temperature ranges of 1100-1200F and 1300-1400F. Controlled amounts of distortion were provided in unwelded plate by mechanical bending; distortion in welded plates was provided by jigging the restraint control. Drop-weight tear tests were conducted to assess the effect of the straightening parameters on the notch-toughness behavior of the respective steels. (Author)

Pattee, HE Evans, RM Monroe, RE
Battelle Memorial Institute, (SR185) SSC-207, 1970, 50p

Contract N00024-68-C-5324

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AD-710521

327677
ANNUAL REPORT TO THE SHIP STRUCTURE COMMITTEE, 1 JULY 1968- 30 JUNE 1969
The purpose of the Committee is to conduct an aggressive research program which will, in the light of changing technology in marine transportation, improve the design, materials, and construction of the hull structure of ships by an extension of knowledge in those fields for the ultimate purpose of increasing the safe operation of ships. (Author)

Ship Structure Committee SSC-203, Nov. 1969, 31p

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327678
BIENNIAL REPORT OF THE SHIP STRUCTURE COMMITTEE
This is the biennial report of the Ship Structure Committee to the convening authority, the Department of Transportation, covering and summarizing the activities of the committee and its affiliated research groups for the period 1 June 1966-1 June 1968. (Author)

Ship Structure Committee SSC-187, June 1968, 30p

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AD-675022

327679
EFFECT OF SURFACE CONDITION ON THE EXHAUSTION OF DUCTILITY BY COLD OR HOT STRAINING
The compressive prestrain (exhaustion limit) needed to cause brittle behavior in subsequent tension was found to be much higher in ABS-B steel bars with surfaces machined by about 0.030 in. before straining than with as-rolled surfaces, even more so when the surfaces were machined after straining. Removal of the strained surface caused a small increase of exhaustion limit even when the surfaces had been machined before prestraining. In all cases the increase was larger for bars prestrained at 550F than at 70F. The surface

effect was found stronger than in earlier tests with an ABS-C steel. In addition the microhardness was found to rise gradually in a 0.030 in. layer adjacent to the surface and to reach a peak at the surface itself in all as-rolled or as-strained surfaces. The surface damage from an unfavorable rolling history permits an easier surface embrittlement by hot straining in a region of strain concentration close to a weld and creates a dangerous trigger of brittle fracture, as is indicated by service fractures starting at such regions. A study of the rolling and straining history causing such weak regions could help their prevention. (Author)

Dvorak, J Mylonas, C
Brown University, (SR-158) Prog Rpt. SSC-185, July 1968, 46p

Contract NObs-88294

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AD-672897

327680
TWENTY YEARS OF RESEARCH UNDER THE SHIP STRUCTURE COMMITTEE

The salient results of two decades of research into such broad areas as materials, physical and qualification tests, nondestructive testing of welds, stress distribution, data from ships in service, and bending moment determination by models are presented. The brittle fracture phenomenon is attacked from a number of fundamental views: variation of composition and microstructure, prior strain and thermal history, rate of loading, stress intensity and distribution, effect of flaws, and variation of test method. All these bits of research are shown to have contributed to the attainment of an engineering solution. Several of these areas are further discussed. Stress distributions at various geometrical discontinuities are reported as are those arising from temperature gradients. Stress intensities measured on ships in service are presented as are the long-term predictions from these measurements. The effect of mill practice on material performance is discussed. The current effort of developing generalizations from results of specific research is described. The trend of the future, the adaptation of computer to exploit generalizations for analysis of whole systems of structure, is set forth. Finally, a listing of nearly 200 reports is given along with information on how to obtain them from Federal repositories. (Author)

Availability: Published in Society of Naval Architects and Marine Engineers n10 1967.

Heller, SR Lytle, AR Nielsen, RJ Vasta, J
SSC-182, Dec. 1967, 47p

ORDER FROM: NTIS

AD-663677

327681
CLEAVAGE FRACTURE OF SHIP PLATES AS INFLUENCED BY SIZE EFFECT

The report contains a description of tests made to determine why ship plates crack in service. The tests were based upon the hypothesis that the cracks begin at points where there are severe geometrical stress-raisers and that the tendency for the plates to crack increased, for specified geometrical characteristics, with an increase in the notch-sensitivity of the steel. (Author)

Illinois University, Urbana, (SR-93) SSC- 3, Aug. 1946, 143p

Contract NOBS-31224

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AD-646363

327682
BIENNIAL REPORT OF THE SHIP STRUCTURE COMMITTEE

Contents: Authority for the Ship Structure Committee; Organization of the Ship Structure Committee; Current Ship Structure Committee organization directory; Research projects and reports; Five year program for Ship Structure Committee research; American Council of the International Institute of Welding; Statistical report of structural failures of steel merchant ships to March 1966.

Ship Structure Committee SSC-176, June 1966, 30p

ORDER FROM NTIS

AD-641333

327683
AN UNMANNED SYSTEM FOR RECORDING STRESSES AND ACCELERATIONS ON SHIPS AT SEA

In order to obtain long-term statistical data on wave-induced bending moments, two dry-cargo ships have been equipped with stress transducers and automatic magnetic-tape recording instrumentation. One of these ships has also been equipped with accelerometers to provide information on seaway-induced loads on cargo. The transducers and their installation are described, as well as the data conditioning units, the tape recorder, and the programmer which allows sampling of the data at preselected intervals and continuous recording when pre-set stress levels are exceeded. The system has performed beyond expectation: data have been obtained on 36 round-trip voyages representing almost three ship-years of operation. Versatility of the unit in handling a variety of data inputs and adapting to various data reduction methods has been demonstrated. In addition, the data tapes are available for future analysis in a broad spectrum of naval design applications. Experience gained to date will permit future installations to be handled expeditiously and at minimum expense, with a high degree of reliability of the unit assured in service. (Author)

Fritch, DJ Bailey, FC
Lessells and Associates, Incorporated, (SR-153) Prog Rpt. SSC-150, PR-1, June 1963, 26p

Contract NOBS-77139

ORDER FROM: NTIS

AD-635079

327684
AN INVESTIGATION OF THE INFLUENCE OF DEOXIDATION AND CHEMICAL COMPOSITION ON NOTCHED-BAR PROPERTIES OF SEMIKILLED SHIP STEEL

The data presented in this paper show that 200-pound semikilled laboratory heats can be made with ample reproducibility for use in studying the influence of chemical composition and deoxidation upon the transition-temperature characteristics of ABS Class A and Class B plate steels. The transition temperature of steels of the Class A and Class B types was found to be progressively raised, and to an appreciable extent, by increasing the carbon phosphorus, and vanadium contents within the limits studied in this investigation. Limited data indicated that increased sulphur did not raise the transition temperature but possibly lowered it. In the range in which sulphur occurs in commercial steels, it would not be expected to have a significant effect. In order to establish definitely the effect of silicon content, more data are needed. The transition temperature was definitly lowered by increasing the manganese content in the range covered in this investigation. The transition temperature was also lowered by decreasing the finishing temperature of the hot-rolled plate, the effect being quite pronounced. (Author)

Prepared in cooperation with NRC, Contract NObs-50148.

Banta, HM Frazier, RH Lorig, CH
(SR-110) Final Rpt. SSC- 49, PR-1, June 1952, 99p

Contract NOBS-50020

ORDER FROM NTIS

AD-635081

327685
BRITTLE FRACTURE OF MILD STEEL IN TENSION AT-196 C

The tensile fracture behavior of a mild steel at-196 C was studied in some detail. With the aid of long thin strip specimens loaded at controlled crosshead speeds between 0.00089 and 0.16 in./min, the strain pattern and microscopic changes preceding fracture were observed, and the magnitude local strain was measured. Specimens heat-treated to alter the tendency toward brittle behavior, but maintaining ferrite-pearlite structures, were also examined. Under these conditions, all the Luder's bands display microcracks in some ferrite grains. However, the as-received and normalized specimens do not fracture at low yield stresses (slow loading speeds) during the spread of the Luder's bands. By raising the loading speed, a critical stress is reached when fracture occurs after a delay time. The formation of microcracks and fracture is always preceded by gross yielding. On further increasing the loading rate, the fracture stress rises along with the yield stress. Deductions from the dislocation pile-up theory of fracture in polycrystalline metals are

not compatible with the experimental data. It is concluded that the microcrack model suggested by Low is more appropriate. Some observations on the creep occurring in Luder's bands during their propagation at-196 C are included. (Author)

See also AD-264 524.

Owen, WS Averbach, BL Cohen, M
Massachusetts Institute of Technology, (NS-011-078) Prog Rpt. SSC-109, Nov. 1957, 37p

Contract NOBS-65918

ORDER FROM: NTIS

AD-635082

327686

EVALUATION OF NOTCH SENSITIVITY OF MILD STEEL SHIP PLATE BY DIRECT EXPLOSION TEST

An investigation was made to determine whether variation in welding procedure, primarily welding electrodes, had an appreciable effect on the notch sensitivity of the finished joint and whether this effect was comparable to that produced by a difference in the quality of the prime plate.

Mikhalapov, GS
Metallurgical Research & Development Co., Inc, (SR-120) Final Rpt. SSC- 43, Mar. 1951, 28p

Contract NOBS-50464

ORDER FROM: NTIS

AD-635107

327687

CAUSES OF CLEAVAGE FRACTURE IN SHIP PLATE, HIGH YIELD STRENGTH STRUCTURAL STEEL

The primary objective of the investigation was to study the effect of variations in steel composition on the temperatures at which the mode of failure changed from ductile shear to brittle cleavage type. These transition temperatures were determined by means of tension tests on notched plates and welded structural assemblies. Three types of specimens were used, two simple notched specimens and one that provided restraint to plastic flow at a corner produced by welding together steel plates set along three mutually perpendicular planes. The specimens were tested in tension at various temperatures and at a low rate of strain in order to determine the transition temperatures of four different heats of high yield strength structural steels. Auxiliary tests were conducted by using a simple bend test to determine the effect of welding on the behavior of the steels. Results of the tests show that the four high yield strength structural steels used in this investigation, when tested in the form of restrained welded specimens, have transition temperatures that vary from-65F for one of the steels, to as high as-75F for one of the others. The tests of notched specimens showed transition temperatures for a particular steel that were approximately 50F lower than those indicated by tests of the large specimens. However, it was found that the steels are rated in the same order of transition temperatures by all three of the tests.

Boodberg, A Parker, ER
California University, Berkeley, (SR-92) Final Rpt. SSC- 28, Sept. 1949, 96p

Contract NOBS-31222

ORDER FROM: NTIS

AD-635108

327688

THE EFFECT OF CYCLIC STRESS ON THE TRANSITION TEMPERATURE OF STEEL

This report concerns an investigation to determine if prior fatigue would affect the transition temperature curves in impact of ship steels. Tests were made on two shipbuilding steels, B and W, the greater amount of work having been done on steel B. A combination fatigue-impact specimen was designed and used. This specimen was round with a circumferential notch and could be tested in impact by sawing off the tapered ends necessary for holding in the fatique machine. As testing proceeded, it was found that fatigue cracks were developing at the base of the notch both above and below the endurance limit. When specimens were cyclically stressed so as to avoid fatigue cracks, the resulting transition curve showed little deviation from the original curve presumably due to the low stress of the prior fatigue. A series of specimens of steel B were prestrained in tension prior to testing in impact with a marked shift of the transition curve resulting. (Author)

Jacques, HE
Massachusetts Institute of Technology, (SR-101) Final Rpt. SSC- 31, July 1949, 45p

Contract NOBS-25391

ORDER FROM: NTIS

AD-635109

327689

CLEAVAGE FRACTURE OF SHIP PLATES AS INFLUENCED BY SIZE EFFECT

The report contains a description of tests made to determine why ship plates crack in service. The tests were based upon the hypothesis that the cracks begin at points where there are severe geometrical stress-raisers and that the tendency for the plates to crack increases, for specified geometrical characteristics, with an increase in the notch-sensitivity of the steel. Plates with nominal widths of 72, 48, 24 and 12 inches were tested. The tests were planned to determine: (1) The relative energy-absorbing capacity and strength of plates of the six kinds of steel. (2) The relation between the width of the plates and their strength. (3) The relation between the temperature of the plates and their strength and energy-absorbing capacity. (4) The relation between the type of fracture and energy-absorbing capacity of the plates. (5) The correlation of the V-notch impact test and the wide plate test.

Wilson, WM Hechtman, RA Bruckner, WH
Illinois University, Urbana, (SR-93) SSC- 10, June 1947, 168p

Contract NOBS-31224

ORDER FROM: NTIS

AD-635148

327690

METALLURGICAL QUALITY OF STEELS USED FOR HULL CONSTRUCTION

To obtain definite information concerning the relationships among chemical composition, underbead weld cracking, and the mechanical properties, especially the tensile and notched-bar impact characteristics, a series of 30 laboratory heats was made and studied in the hot-rolled state to determine the individual influence of each of the following constituents when varied over a range sufficiently broad to definitely establish the trend of the effect: carbon, manganese, silicon, molybdenum, vanadium, and aluminum. For a standard chemical composition, a typical HTS analysis was selected, and the elements studied were then varied one at a time in this standard composition.

Sims, CE Banta, HM Walters, AL
Battelle Memorial Institute, (SR-87) Prog Rpt. SSC- 13, Nov. 1947, 74p

Contract NOBS-31219

ORDER FROM: NTIS

AD-635149

327691

THE FUNDAMENTAL FACTORS INFLUENCING THE BEHAVIOR OF WELDED STRUCTURES UNDER CONDITIONS OF MULTIAXIAL STRESS, AND VARIATIONS OF TEMPERATURE, STRESS CONCENTRATION, AND RATES OF STRAIN

A detailed study was made of a low carbon ship plate steel, both 'as received' and 'as welded', by utilizing hardness tests and eccentric notch bar static tension tests at various temperatures. Considerable nonuniformity was revealed in the 'as received' plate, that is, localized areas showed relatively high transition temperatures. A brittle-ductile transition zone was found to exist between -40 and-80F for the investigated steel. A zone of maximum hardness occurred at the junction of the weld metal and the heat affected zone, from which the hardness (Rockwell B) approached that of the unaffected plate. A zone of minimum ductility (eccentric notch strength) was found 0.3 to 0.4 inch from the weld centerline. This zone was located by using the eccentric notch bar tension test at low temperatures. The zone of low ductility is thought to be the zone which is heated to the maximum subcritical temperature, with the further possibility of embrittlement by strain aging and intermediate transformation products. (Author)

Sachs, G Ebert, LJ Dana, AW
Case Institute of Technology, (SR-99) Tech Rpt SSC- 24, May 1949, 37p

Contract NOBS-45470

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AD-635171

327692

TWELVE INCH FLAT PLATE TESTS

The report contains an account of the testing of the "A", "C", "Bn", "Br", "Du" and "E" steels. The tests d are tension tests run at various temperatures on specimens 24 in. long, 12 in. wide and 3/4 in. thick having a central internal notch one-quarter of the width of the plate with ends of the notch 0.010 inch wide made by a jeweler's hacksaw. The load was applied in the direction of the rolling. This program was undertaken because it was believed that tests made under standardized conditions would furnish additional information regarding the behavior of these steels, and would provide a standard that could be used to judge the efficacy of tests of small sized specimens adapted for use as acceptance tests. The report contains tables giving the load at first visible crack, at maximum load, and at ultimate load, together with the energies computed to those loads. Load-elongation curves for each specimen tested are included, together with diagrams showing maximum load, plotted with temperatures as abscissas, and diagrams showing energy to maximum load plotted with temperatures as abscissas. The transition temperature zones of these steels based on the 12in wide plate tests are reported based on energy considerations and on the mode of the fracture. (Author)

Carpenter, ST Roop, WP Barr, N Kasten, E Zell, A
Ship Structure Committee, (SR-98) Prog Rpt. SSC- 21, Apr. 1949, 111p

Contract NOBS-45521

ORDER FROM: NTIS

AD-635172

327693

FATIGUE TESTS OF SHIP WELDS

The report summarizes the results of an investigation of the relative fatigue behavior of plates with (a) longitudinal ship welds, (b) reinforced and unreinforced flame cut openings, and (c) flame cut edges. The specimens, of the order of 12 to 17 inches wide and 7 feet long, were constructed from 3/4in plate of semi-killed shipbuilding steel and were subjected to zero-to-tension loading in especially built fatigue testing machines. The stress range generally was 0-30,000 psi tension. Fatigue control specimens were flat plates of tensile-coupon shape with flame cut edges. It was concluded that for a stress range of approximately zero-to-30,000 psi tension the characteristics of the flame cut edge were not significant in determining fatifue life within 500,000 cycles of stress. In comparison to the control specimens, longitudinal welds showed a greatly reduced fatigue life. All fatigue fractures started in the weld metal itself, usually in regions of porosity, deep surface ripples, poor root fusion, etc. Improved fatigue life for specimens with ground weld surfaces indicates that surface ripples, folds, or pits are incipient points of fatigue failure. The change in width from 12in to 16in is not believed to be a significant. All specimens with reinforced openings had a very short fatigue life (less than 30,000 cycles). Unreinforced, as cut, openings had a greater fatigue life than the reinforced openings. Treatment of the surface by grinding or by heat treatment markedly increased the fatigue life. (Author)

Hollister, SC Garcia, J Cuykendall, TR
Cornell University, (SR-89) Final Rpt. SSC- 14, Feb. 1948, 110p

Contract NOBS-31218

ORDER FROM: NTIS

AD-635181

327694

METALLURGICAL QUALITY OF STEELS USED FOR HULL CONSTRUCTION

This report discusses some of the pertinent factors, especially banding and homogenization, which influence the susceptibility of HTS hull steel to underbead weld cracking. The use of laboratory heats for evaluating various chemical compositions and deoxidation practices is considered. The specific items covered are as follow. (1) The influence of time and temperature upon the homogenization of both average and high chemical composition HTS steels. (2) The effect of various degrees of homogenization upon underbead cracking and tensile properties. (3) The effect of hot reduction upon the response to homogenizing treatments. (4) The demonstration of the mechanism of banding in HTS hull steels. (5) A study of the underbead cracking characteristics of quenched and drawn HTS having a yield strength above 75,000 p.s.i. (6) A comparison of the underbead cracking characteristics and mechanical properties of laboratory and commercial HTS hull steels. (Author)

Sims, CE Banta, HM Walters, AL
Battelle Memorial Institute, (SR-87) Final Rpt. SSC- 11, May 1947, 63p

Contract NOBS-31219

ORDER FROM NTIS

AD-635182

327695

DEVELOPMENT OF FILMLESS TECHNIQUE FOR RECORDING DEFECTS IN SHIP WELDS

The U.S. Naval Ordnance Test Station investigated informally the feasibility of a direct-reading or filmless technique in radiography using a 300 mC Cobalt-60 source and a Geiger counter as a detector on a 1-in. thick steel welded test plate furnished by the Long Beach Naval Shipyard. A sketch and a radiograph of the welded test plate are shown. The tests were based on transmitted radiation, and the time required for a preset number of counts on a Potter chronograph was a function of the radiation intensity passing through a specific area of the weld. The larger the void, the shorter the time indicated on the counter. The memorandum also stated that preliminary tests indicated that it was feasible to place both the radiation source and the detector on the same side of the weld and to use a lead sheet radiation scatterer on the other side. All the following experiments were conducted with a steel plate as as a scatterer instead of the originally adopted lead sheet because the yield of the former was higher. Even though only radioisotopes are mentioned as radiation sources in the project assignment, the investigation was extended to include X-rays since a higher radiation intensity was expected from the 250 kvp X-ray equipment than from the available weak gamma source of 150 mC. The detectors used in these tests were as follows: a scintillator, an industrial Geiger counter (radiation monitor), and cadmium sulfide and cadmium selenide crystals.

Bujes, JI
Naval Ordnance Test Station, Ship Structure Committee Prog Rpt. SSC-104, Feb. 1957, 35p, 2 Ref.

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AD-635673

327696

LOW-CYCLE FATIGUE BEHAVIOR OF AXIALLY LOADED SPECIMENS OF MILD STEEL

Studies have been conducted to evaluate the low-cycle high-stress fatigue behavior of several ship steels under a variety of loading conditions. On the basis of these tests and related studies reported in the literature a general hypothesis describing the cumulative effect of plastic deformations has been developed. With this hypothesis the deformation obtained in a single loading may be used to describe or predict the basic low-cycle fatigue behavior of mild steels for lives up to approximately 1,000 cycles. Furthermore, limited correlations with existing data from other investigations suggest that it may also be possible to extend the hypothesis to metals other than steel. (Author)

Yao, JTP Munse, WH
Illinois University, Urbana, (SR-149) Prog Rpt. SSC-151, June 1963, 78p

Contract NOBS-77139

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AD-635696

327697

EVALUATION OF IMPROVED MATERIALS AND METHODS OF FABRICATION FOR WELDED STEEL SHIPS

This report covers tests made on the project steels using various modifications of the test specimens employed in the work described by the first

progress report and with notched tension specimens. It was the object of these modifications to obtain the same transition temperatures for the project steels that were obtained from the full-scale hatch-corner test specimens studied at the University of California. Other tests of all-weld-metal specimens and specimens welded with E6020 electrodes are included. A few preliminary observations on the initiation of fracture in the test specimens used are described.

Bennett, RW Kline, RG Forman, M Rieppel, PJ Voldrich, CB
Battelle Memorial Institute, (SR-100) Prog Rpt. SSC- 33, Nov. 1949, 95p

Contract NOBS-45543

ORDER FROM: NTIS

AD-635762

327698

INVESTIGATION OF MEANS FOR EVALUATING THE QUALITY OF HULL PLATE STEEL BY TESTS CONDUCTED ON FURNACE OR LADLE SAMPLES

A simple but reliable method for evaluating the notch sensitivity of hull steel before the steel has been rolled into plate was sought. Several series of both the low-and high-silicon steels were made both with and without aluminum deoxidation and tested by standard V-notch Charpy impact tests and by a round Charpy impact bar, which was developed to save machining time and cost. Notched-bar impact values of the high-silicon steels with or without aluminum deoxidation, are low and not significantly different. A marked superiority of the aluminum-killed steels is apparent when these steels are properly normalized and also when these or the low-silicon steels are hot rolled at proper temperatures. Specimens hot rolled and then subjected to strain aging show a further decrease in notched-bar impact resistance of the nonaluminum as compared with the aluminum-killed steels. A series of notched-bend bar tests qualitatively indicated the same trends by fracture appearance and manner of breaking, but no quantitative evaluations were obtained from static bend tests. (Author)

Heer, WGN Herres, SA Lorig, CH
Battelle Memorial Institute, (SR-97) Prog Rpt. SSC- 12, Oct. 1947, 50p

Contract NOBS-45030

ORDER FROM: NTIS

AD-635763

327699

THE EFFECTS OF WIDTH AND THICKNESS ON STRENGTH, ENERGY ABSORPTION AND TRANSITION TEMPERATURE FOR INTERNALLY NOTCHED FLAT STEEL PLATES

This report contains the results of tensile tests made on geometrically similar steel specimens. Tests were made in a systematic manner with Aspect Ratios (width divided by thickness) varying from 4 to 20. Each specimen was internally notched with a central transverse notch having a length equal to 1/4 of the width of the speciment. The ends of the notches terminated with a drilled hole. The diameter of the drilled holes was made proportional to plate thickness. Steel plates ranging in 'as rolled thickness', from 1/2 inch to 11/2 inch were investigated from two heats of steel. The results of the tests are classified on the basis of strength, energy absorption, and transition temperature. It was found from this investigation that dimensional similarity of specimens does not assure geometrical similarity of plastic strain patterns. Therefore, the geometrical and metallurgical effects of thickness on transition temperature could not be segregated on the basis of geometrically similar specimens in this investigation. (Author)

Carpenter, ST Roop, WP Zell, A Kasten, E
Swarthmore College Prog Rpt. SSC- 44, Nov. 1951, 90p

Contract NOBS-45521

ORDER FROM: NTIS

AD-635764

327700

CORRELATION OF LABORATORY TESTS WITH FULL SCALE SHIP PLATE FRACTURE TESTS: ANALYSIS OF TRUE-STRESS TRUE-STRAIN DATA ON PROJECT STEELS

The results of a study of the flow and fracture strengths of the project steels are considered. It appears that the flow-and fracture-strength concept of failure proposed by Ludwik is not adequate to account for the results obtained. The flow properties of the steels were studied as a function of temperature and prestrain. The test results were found to be adequately described by the expression, sigma = sigma sub o delta to the n power, in which sigma and delta are respectively true stress and natural strain, while sigma sub o and n are constants. Sigma sub o has been found to vary regularly with temperature while n has been found to undergo a transition for most of the steels at sufficiently low temperatures. Both sigma sub o and n appear to have fundamental significance and should ultimately be correlated in some manner with the engineering properties of the steels. (Author)

Klier, EP Mack, JO Wagner, FC Gensamer, M
Pennsylvania State University, University Park, (SR-96) Prog Rpt. SSC-19, June 1950, 65p

Contract NOBS-31217

ORDER FROM: NTIS

AD-635766

327701

DIRECT EXPLOSION TEST FOR WELDED ARMOR AND SHIP PLATE PRIME AND WELDED PLATE TESTS

The direct explosion test has been utilized to determine the relative resistance of welded and unwelded specimens to shock loading. The tests were conducted using a special explosive which is detonated in direct contact with the specimen under controlled conditions. Repetitive tests have demonstrated the excellent reproducibility of the test. (Author)

Snelling, WA
Trojan Powder C SSC- 4, Aug. 1946, 27p

Contract NOBS-31223

ORDER FROM: NTIS

AD-635769

327702

CRACKING OF SIMPLE STRUCTURAL GEOMETRIES; THE EFFECTS OF EDGE NOTCH GEOMETRY ON FLAT STEEL PLATES [Progress rept. no. 1]

This report covers an investigation to determine the relative cracking tendency of simple geometries common to ship structures and presents the results of tensile tests on edge notch specimens. The edge notched specimens were 15in wide by 40in long and prepared from 3/4in thick Dn steel. The edge notching consisted of notches at the mid-length of the specimen and notches separated by a reduced width portion. The results of the tests are classified on the basis of strength, energy absorption and transition temperatures. The results indicate that there is no marked difference in transition temperature for the various types of edge notches, which included a jeweler's hack saw cut at 90 to the plate edge, a similar flame cut notch, flame cut notches with various included angles, flame cut semi-circles, and notches similar to the foregoing but having an elongated reduced width section. There is, however, a considerable difference in the action of the specimens with regard to strength and energy absorption. (Author)

Carpenter, ST Linsenmeyer, RF
Swarthmore College, (SR-118) Prog Rpt. SSC- 51, May 1952, 83p

Contract NObs-50250

ORDER FROM: NTIS

AD-635786

327703
INVESTIGATION OF MEANS FOR EVALUATING THE QUALITY OF HULL PLATE STEEL BY TESTS CONDUCTED ON FURNACE OR LADIE SAMPLES

A simple but reliable method for evaluating the notch sensitivity of hull plate steel before the steel has been rolled into plate was sought. Tests made on cast ladle samples from open hearth heats verified the results obtained on laboratory steels which showed that small hot-worked ladle samples will distinguish relatively large differences in the notched-bar impact resistance of hull plate steels. Correlation between the deoxidation practice and the notched-bar impact properties was obtained for both the commercially rolled plate and the hot-worked ladle samples although the actual impact values for the ladle samples were higher than for the plate samples. The Walker Wedge-impact test was investigated as a possible method for evaluating the quality of hull plate steel on samples poured from the furnace or ladle. The Walker wedge test was not sufficiently sensitive to distinguish a difference in impact resistance between an aluminum-killed steel and a silicon-killed steel when each was either in the as-cast or normalized condition. Notched-bar impact tests showed an appreciable difference in the impact resistance of these two steels. When the as-cast surface was removed by grinding, normalized wedges free from defects failed to break at a testing temperature of minus 80F.

Davis, JA Herres, SA Greenidge, CT Lorig, CH
Battelle Memorial Institute, (97) Final Rpt. SSC- 20, Nov. 1948, 55p

Contract NOBS-45030

ORDER FROM: NTIS

AD-635787

327704
THE FUNDAMENTAL FACTORS INFLUENCING THE BEHAVIOUR OF WELDED STRUCTURES UNDER CONDITIONS OF MULTIAXIAL STRESS, AND VARIATIONS OF TEMPERATURE, STRESS CONCENTRATION, AND RATES OF STRAIN

An investigation was made to determine the dependence of zones of low ductility in weldments upon the steel and upon the welding conditions and heat treatment. The ductility was evaluated by means of eccentric notch-bar tension tests conducted at various low temperatures. A zone of low ductility was found in two low carbon ship plate steels at a distance of 0.3-0.4 in from the weld centerline when the weldments were made with 100F preheat and interpass temperature. A 400F preheat and interpass temperature improved the ductility in the critical zone, lowering the transition temperature from-20F to-45F. A 1100F postheat practically eliminated the zone of lowered ductility, the transition temperature being lowered to-70F. Temperature measurements made during welding showed that the embrittled region was not heated above the lower critical temperature. No change in microstructure could be noted between the critical zone and the unaffected base plate. Microhardness tests showed only slight hardening in the embrittled region. The occurrence of the embrittled region is thought to be due to some subcritical temperature phenomena which may be the supersaturation and precipitation of carbon or carbides from the alpha phase. (Author)

See also AD-635 762.

Klingler, LJ Ebert, LJ Baldwin, WM, Jr
Case Institute of Technology Tech Rpt. SSC- 34, Nov. 1949, 58p

Contract NOBS-4570

ORDER FROM: NTIS

AD-635791

327705
A STUDY ON THE STRUCTURAL ACTION OF SUPERSTRUCTURES ON SHIPS

Starting from the assumption that the hull and the deck house may be considered as beams, to each of which, separately, Navier's hypothesis is applicable, the report gives expressions for the deflections and stresses in the hull and deck house assuming constant section of hull and house; it is shown that the theoretical stress distributions found are of the type observed in the tests. The results of this theory concerning the stresses in the mid-ship section can be arranged in simple tables which permit the prediction of the deviation from the conventionally assumed straight-line stress distribution. The method is equally applicable if a part or all of the deck house consists of aluminum.

Bleich, HH
Columbia University, New York SSC- 48, Dec. 1951, 65p

Contract NObs-50538

ORDER FROM NTIS

AD-635792

327706
CORRELATION OF LABORATORY TESTS WITH FULL SCALE SHIP PLATE FRACTURE TESTS

The report summarizes the work done on a series of edge-notched tensile bars prepared from the project steels. Evidence is presented to show that for the test specimen used, reasonable agreement exists between the transition temperatures obtained on the basis of per cent fibrous fracture and the transition temperatures for the large plate tension tests. It is further shown that there is lack of agreement between transition temperatures based on fracture appearance and transition temperatures based on energy absorption for this test. Lateral contraction measurements and total elongation measurements are given and show general conformity with energy absorption measurements, although much scatter of the data precludes a strict comparison. (Author)

See also AD-675 766.

Wagner, C Klier, EP
Pennsylvania State University, University Park, (SR-96) Prog Rpt. SSC-22, Oct. 1948, 29p

Contract NOBS-31217

ORDER FROM: NTIS

AD-635793

327707
CORRELATION OF LABORATORY TESTS WITH FULL SCALE SHIP PLATE FRACTURE TESTS: A STUDY OF STRAIN GRADIENTS

Strain gradients normal to fracture surfaces were determined. These fracture surfaces were developed under the following conditions of test: (1) V-notch Charpy bars broken by impact at various locations within the transition zone, (2) V-notch Charpy bars bent, but not completely broken, by impact above the transition temperature, (3) slow bend Schnadt type bars broken below the transition temperature, and (4) 72-inch wide, center notch, tensile specimens broken with ductile and brittle behavior. The strain gradients were studied by means of hardness tests, metallographic methods and X-ray analysis. It is concluded that true cleavage separation is not accompanied by a measurable strain gradient but most 'brittle' or 'cleavage' fractures, so classified on the basis of gross appearance, contain some areas separated by a shear mechanism. (Author)

See also AD-635 766.

Klier, EP Wagner, FC Fisher, JL Gensamer, M
Pennsylvania State University, University Park Prog Rpt. SSC- 17, June 1949, 83p

Contract NOBS-31217

ORDER FROM: NTIS

AD-635794

327709
TWELVE INCH FLAT PLATE TESTS (PART I). ASPECT RATIO PROGRAM (PART II)

Part I of this report states the test results for the following steels: W, S-9, S-12, and S-22. The tests of Part I are tension tests run at various temperatures on speciments 24 in long, 12 in wide and 3/4 in thick, having a central internal notch one-quarter of the width of the plate with ends of the notch 0.010 inch wide made by a jeweler's hack-saw. The load was applied in the direction of rolling. The report contains tables giving the load at first visible crack, at maximum load, and at the failure load, together with the energies computed to these loads. Load elongation curves for each specimen tested are included, together with diagrams showing maximum load, vs. temperature and diagrams showing energy to maximum load vs.

temperature. The character of the fracture as determined by the percentage of shear failure is also given. The transition temperature zones of these steels on the basis of both energy considerations and the mode of the fracture are reported. Part II of this report describes the aspect ratio program now under way to determine the effect of plate width and thickness on transition temperature. (Author)

Rept. on Tension Tests of Flat Internally-Notched Plates.

Carpenter, ST Roop, WP Kasten, E Zell, A
Swarthmore College, (SR-98) Prog Rpt. SSC- 35, Dec. 1949, 54p

Contract NOBS-45521

ORDER FROM: NTIS

AD-635797

327710

AN INVESTIGATION OF THE INFLUENCE OF DEOXIDATION AND CHEMICAL COMPOSITION ON NOTCHED-BAR PROPERTIES OF SEMIKILLED SHIP STEEL

Formulas for calculating tensile properties and notched-bar transition temperatures were developed from data obtained on a comprehensive series of experimental steels. For a particular strength level, steels with higher manganese-carbon ratios have lower transition temperatures. The influence of nitrogen in raising the strength and transition temperature of semikilled steel was studied. Heats treated with zirconium in amounts ranging from 0.06 to 0.10 per cent were made and tested. Small additions of aluminum to steels with low silicon contents usually lowered the tear-test and Charpy transition temperatures. The presence of titanium in excess of 0.02 per cent seems to increase the transition temperature of both Type A and Type B type ship plate. Increasing the ferritic grain size of a particular steel by austenitizing at increasingly higher temperatures raises the transition temperature.

Proj. NS-731-036, See also AD-635 791.

Frazier, RH Boulger, FW Lorig, CH
Battelle Memorial Institute, (SR-110) Prog Rpt. SSC-053, Nov. 1952, 98p

Contract NOBS-53239

ORDER FROM: NTIS

AD-635871

327711

CAUSES OF CLEAVAGE FRACTURE IN SHIP PLATE: HATCH CORNER DESIGN TESTS

This report deals with the testing of 12 full scale hatch corner specimens. One of these was essentially the same as the hatch corner used in the earliest 'Liberty' type ships, and the same as has been used in the earlier test. Two of the specimens tested were invalid due to laminated plates. The others included the modifications of: continuous longitudinal grider; full penetration welds; U.S.C.G. Code 5 and Code 1 modifications, and the effectiveness of the doubler plate in the Code 5 modification; the British Code 1A modification; extended coaming; diagonal braces at the bottom of the girder joint; a new design similar in configuration to the hatches used on Victory type ships; a new design involving a hot-formed double radius corner plate. The strength and energy absorbing abilities of each were determined. The use of an extended coaming was found to be a very effective and simple modification. The design utilizing the formed corner was far superior to all other and produced definitely ductile behavior, a quality which has not before been found in welded hatch corners. (Author)

DeGarmo, EP Boodberg, A
California University, Berkeley, (SR-92) Final Rpt. SSC- 16, Dec. 1947, 90p

Contract NOBS-31222

ORDER FROM: NTIS

AD-636739

327714

CAUSES OF CLEAVAGE FRACTURE IN SHIP PLATE: HATCH CORNER TESTS

This report deals with the testing of seven large welded steel specimens similar in design to a square hatch corner of a ship. These were the last seven in a series of 26 such specimens which were tested to determine the performance of seven types of steel when built into a welded structure which had severe restraint to plastic flow due to a designed discontinuity. One of the last seven specimens was constructed of a 3-1/3 per cent nickel alloy steel and two from a low carbon steel having 0.82 per cent manganese. The others were made of three grades of plain carbon ship quality steel. Preheating at 400F was used on three of the specimens. The effect of preheating was very beneficial. The specimen constructed from nickel steel absorbed rather little energy before failure. This was attributed to the high yield strength of this material which prevented plastic flow of the plate before failure of the welded joints. (Author)

DeGarmo, EP Meriam, JL
California University, Berkeley, (SR-92) SSC- 5, Oct. 1946, 47p

Contract NOBS-31222

ORDER FROM: NTIS

AD-636743

327715

CAUSES OF CLEAVAGE FRACTURE IN SHIP PLATE: FLAT PLATE TESTS AND ADDITIONAL TESTS ON LARGE TUBES

The materials used in this investigation were three lots of semi-killed hull quality steels, one lot of nickel alloy, one lot of fully-killed, and one lot of fully-killed quenched and drawn steel. The specimens used in the principal program were 3/4 inch thick plates containing a narrow transverse slot having a length equal to one fourth of the specimen width. These were tested in tension in widths ranging from 12 inches to 108 inches. Tests were made at each of a number of temperatures in order to determine the temperature at which the mode of failure changed from shear to cleavage type. In the tests, observations were made of the following: the maximum load, load at development of cracks, fracture load, energy absorbed to maximum load, mode of fracture, strain distribution over the faces of plates and thickness reductions near the lines of fracture.

Davis, HE Troxell, GE Parker, ER Boodberg, A O'Brien, MP
California University, Berkeley, (SR-92) Final Rpt. SSC- 8, Jan. 1947, 196p

Contract NOBS-34231

ORDER FROM: NTIS

AD-636746

327716

FATIGUE TESTS OF SHIP WELDS

The results of fatigue tests of twenty-eight specimens representing typical ship welding problems are described. Stress range of zero-to-30,000 psi tension was applied to 11 1/2 in wide plates having a longitudinal weld in the direction of tension and to 17 in plates with central holes whose boundary was flame cut, flame cut and ground, flame cut and machined, and which had welded reinforcing inserts. Variation in number of weld passes in the longitudinal weld from 1 to 3, each side, is not believed to affect the fatigue behavior significantly, but irregularities such as folds or pits in the weld surface are shown to act as stress raisers and to initiate failure. Tests were made on welds whose surfaces were ground smooth and flush with those of the plate. Two specimens of 50% greater width, and two of another steel, showed no difference in fatigue behavior from the balance of specimens of similar nature. The backstep method of laying weld passes is shown to be superior to the continuous technique. The results of tests of eight specimens with central holes emphasizes the fact that discontinuities of form and stiffness require special treatment to provide paths free of stress raisers. (Author)

Hollister, SC Garcia, J Cuykendall, TR
Cornell University, (SR-89) Prog Rpt. SSC- 7, Dec. 1946, 116p

Contract NOBS-31218

ORDER FROM: NTIS

AD-636749

327717
CORRELATION OF LABORATORY TESTS WITH FULL SCALE SHIP PLATE FRACTURE TESTS

The report summarizes the results which have been obtained to date on notched beam impact testing, and metallographic examination of the ship plate steels. In Part I of this report it is shown that the standard Charpy impact test using either the V-or keyhole-notch or a special 3/4 in. wide specimen is not capable of evaluating the ship plate according to the data which have been obtained for large plate specimens. However, by using Charpy keyhole-notch specimens which have been strained 10% in tension and which have been allowed to stand at room temperature for one month, test data have been obtained which allow the prediction with fair accuracy of the transition temperature in the large plates. In Part II the microstructures of the project steels have been considered. It has been shown that no simple alteration in microstructures can be found to account for the profound variation in energy absorption characteristics in the series of steels which have been studied. It has been shown that variations in grain size in a given steel cause large changes in the energy absorption characteristics of that steel. (Author)

Gensamer, M Klier, EP Prater, TA Wagner, FC Mack, JO
Pennsylvania State University, University Park, (SR-96) Prog Rpt. SSC-9, Mar. 1947, 133p

Contract NOBS-31217

ORDER FROM: NTIS

AD-636752

327718
LOCAL YIELDING AND EXTENSION OF A CRACK UNDER PLANE STRESS

The size of locally yielded regions, the stress distribution, and displacements attending a crack in tension under plane stress have been calculated by extending the work of Dugdale and others. Methods have been developed to take work hardening and unloading into account. The displacements and plastic-zone sizes measured in edgeslotted silicon steel coupons are found to be in agreement with calculations. Conditions under which plane stress or plane strain are dominant in these edge-slotted specimens have also been determined. Finally, Irwin's fracturetoughness parameter and the conditions for crack extension are formulated in terms of basic material parameters consistent with experiment. (Author)

Rept. includes Fundamentals of Crack Propagation Resistance; Local Strain Measurement.

Hahn, GT Rosenfield, AR
Battelle Memorial Institute, (SR164) SSC-165, Dec. 1964, 24p

Contract NObs88348

ORDER FROM: NTIS

AD-610039

327719
TEMPERATURE DISTRIBUTION AND THERMAL STRESSES

An investigation was made to extend the existing knowledge of thermal stresses in ship structures by the study of both physical and mathematical models. The physical floating model was a 10-ft welded box beam simulating the main hull girder of a transversely framed cargo ship. It was subjected to various temperature environments above water, and thermal stresses were measured with foil strain gages. The results of these tests showed excellent agreement at sections remote from the ends of the model with a strength-of-materials approach modified to include any arbitrary transverse temperature distribution. A finite-difference solution to the governing equations of thermo-elasticity was developed for two-dimensional plates and extended to a folded-plate type of box girder. The solution was conducted on the IBM 704 and 7090 computers, and the computer program with slight modification is considered suitable for use in ship-design offices. Solutions were obtained for a variety of thermal conditions with temperatures varying vertically, transversely, and longitudinally. Accurate comparisons were made with both the experimental and the strength-of-materials results. (Author)

Lyman , PT Meriam, JL
California University, Berkeley, (SR161) Final Rpt. SSC-152, June 1964, 38p

Contract NObs78634

ORDER FROM: NTIS

AD-601593

327720
EXHAUSTION OF DUCTILITY AND BRITTLE FRACTURE OF E-STEEL CAUSED BY PRESTRAIN AND AGING

The investigation of static brittle fracture initiation in engineering structures requires first the establishment of a criterion of brittle behavior of the structure as a whole. Such a criterion is obtained by a comparison of the fracture load with the flow limit of an idealized perfectly plastic material. The difference between static fractures at high and low load was related to the magnitude of the plastic strains at regions of strain concentration and to the ductility of the steel. It was found that the ductility depends on the whole history of strain and temperature and is suddenly and drastically exhausted by cold straining of a closely determined amount, and far more easily by straining at about 500 F. This led to the first systematic static brittle fracture initiation of unwelded steel plates at low average net stress, as low as 10% of yield. The ductility of cold strained steel is restored by a heat treatment at about 1100 F or higher. The required duration of heat treatment is shorter for hot than for cold-strained bars and appears to increase with the amount of prestrain, and to decrease when the temperature is raised. A better understanding of the mechanism of fracture initiation makes it now possible to express qualitative macroscopic criteria of fracture based on the strain hardening law and the ductility of embrittled steel and on the strain and stress distribution at a sharp notch in such material. (Author)

Mylonas, C
Brown University, (SR158) Prog Rpt. SSC-162, July 1964, 39p

Contract NObs88294

ORDER FROM: NTIS

AD-603214

327721
RESULTS FROM FULL-SCALE MEASUREMENTS OF MIDSHIP BENDING STRESSES ON TWO C4-S-B5 DRYCARGO SHIPS OPERATING IN NORTH ATLANTIC SERVICE

Records of wave-induced midship bending stresses were obtained on magnetic tape during the past three years using an unmanned instrumentation system. The reduced data cover thirty-four round trip voyages of two instrumented C4-S-B5 (machinery aft) dry-cargo vessels on the North Atlantic trade route. The data represent about 12,000 hours at sea out of five ship-years of operation. Each data point is based on a one-half hour record representing four hours of ship operation. An automatic Probability Analyzer is used in the reduction of data. All available data are presented as plots of rms stress variation and maximum peak-to-peak stress variation vs. sea state (Beaufort Wind Scale). The data were shown to be representative of a class of ships exposed to sea states corresponding to Beaufort Numbers 3-7. (Author)

Rept. on Ship Response Statistics.

Fritch, DJ Bailey, FC Wise, NS
Lessells and Associates, Incorporated, (SR153) Prog Rpt. SSC-164, Sept. 1964, 33p

Contract NObs88349

ORDER FROM: NTIS

AD-605535

327722
MICROMECHANISMS OF CLEAVAGE FRACTURE IN POLYCRYSTALLINE IRON

The initiation and propagation of cleavage microcracks in coarse-grained vacuum-melted ferrite, containing 0.035 and 0.007 per cent carbon, were studied by means of tensile tests carried out between room temperature and-196 C, and by special metallographic procedures. Cleavage microcracks develop in ferrite during the strain-hardening portion of the stress-strain

curve at low temperatures, and are initiated mainly by cracks which form in the carbides. Twinning does not play an important role in crack initiation over the entire temperature range studied. Carbide cracks during plastic deformation at all temperatures investigated, but they lead to microcracks in the ferrite only when the applied stress is high enough to permit the carbide cracks to act as Griffith cracks. Carbide cracks also lead to the formation of large voids during the necking of specimens tested in the ductile and transition temperature regions. Pre-existing twins provide strong barriers to microcrack propagation. Twinning also causes the disappearance of the discontinuous-yield phenomenon at low temperatures. A model for microcrack initiation by carbide cracking is proposed, and the conditions leading to brittle fracture are discussed. (Author)

Report on Metallurgical Structure.

McMahon, CJ, Jr
Massachusetts Institute of Technology Prog Rpt. SSC-161, May 1964, 59p

Contract NObs88279

ORDER FROM: NTIS

AD-600515

327723
MICRO-AND MACROCRACK FORMATION

The formation of cleavage microcracks with a length of the order of one grain diameter is considered to be the initial step in fracture. It is assumed that the stress concentration required for cleavage is supplied by thick slip or twin bands, and the critical width of these yield bands is calculated. For example, in iron with a grain radius of 0.01 cm, the critical slip band width is 0.00002 cm, and this value is compatible with observations in the vicinity of microcracks. The second stage of crack formation involves the semicontinuous propagation of microcracks to form unstable macroscopic cracks. We postulate that plane-strain fractures occur under conditions where thick slip bands are formed in the yielded region in front of an advancing crack. Work is required to extend the initial microcracks, and this incremental work is used to calculate the crack-extension force, Gc, which is required in linear fracture mechanics. In the case of iron, the microcrack-extension force is calculated to be 5000 dynes/cm, and the minimum value of Gc is calculated to be 2,500,000 dynes/cm. This approach emphasizes the three conditions required for fracture: (1) a combination of stress and yield band width sufficient to cause local cleavage; (2) sufficient mechanical energy in the system to propagate the crack; (3) the development of a critical value of the initiation stress in order to continue crack extension. (Author)

Prepared in cooperation with Massachusetts Inst. of Tech., Cambridge under contract NObs-88279.

Averbach, BL
Ship Structure Committee, (SR-136) Prog Rpt. SSC-171, Oct. 1965, 40p

ORDER FROM: NTIS

AD-473496

327724
EFFECT OF SUBSTRUCTURE ON CLEAVAGE IN IRON CRYSTALS

The influence of substructure on the cleavage transition temperature in iron single crystals was investigated. Substructure was introduced by prestraining up to 10% and annealing, with the dislocation density increasing correspondingly from an initial value of about 10 to the 7th power to about 10 to the 10th power per sq cm. The yield properties of the crystals with substructure were somewhat higher while the brittle transition temperature was raised about 40 C. Twinning preceded cleavage in these tests, and all the cleavage microcracks observed were associated with twins. The microcracks were located either along the twin/matrix interfaces or within the twins, but not in the matrix itself nor at intersecting twins. Cleavage appears to be initiated by the action of twinning, rather than by the role of twins as barriers to slip. (Author)

Prepared in cooperation with Washington Univ., Seattle and Massachusetts Inst. of Technology, Cambridge.

Flanagan, WF Averbach, BL Cohen, M
Ship Structure Committee, (SR-136) SSC-133, Progress rept. no. 5, 1962, 22p

Contract NOBS-78541

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AD-270697

327725
THE INFLUENCE OF MECHANICAL FIBERING ON BRITTLE FRACTURE IN HOT-ROLLED STEEL PLATE

Several factors are involved in the formation of fissures on a microscale: the presence of finely dispersed fiber elements, plastic strain, and a stress normal to any plane in which the fiber is aligned. The strain and stress factors were found to different degrees in the various tests, so that the contribution of the extragrain-size effect to transition temperature depended on the test employed and the criterion for transition. A classification was suggested from van der Veen notched slow-bend, to Charpy V-notch, to pure tensile loading, on the basis of decreasing tendency to promote fissuring at transition. Using the van der Veen test and 32-mm fibrous criterion, the transition temperature for controlled-rolled plate is lowered for reasons other than grain refinement by 10-15 C, or 2-3 times that when the temperature is taken at the Charpy V-notch 15 ft-lb level. (Author)

Kapadia, BM English, AT Backofen, WA
Massachusetts Institute of Technology, (SR-147) SSC-138, No. 2, Dec. 1961, 25p

Contract NOBS-72386

ORDER FROM: NTIS

AD-268627

327726
RESTORATION OF DUCTILITY OF HOT OR COLD STRAINED ABS-B STEEL BY HEAT TREATMENT AT 700 TO 1150F

The severe embrittlement caused by a suitable history of strain and temperature has been confirmed also for steel conforming to ABS-B classification. Steel prestrained in compression by about 50% at 70F and subsequently tested in tension fractures at an extensional strain of the order of 1%. Prestraining at 550F by even 25% can cause brittleness in extension at-16F. Local severe embrittlement of this nature has been shown to be the basic cause of the static initiation of brittle failure of structures at low average stress. This is confirmed by service failures, whose origin is frequently traced to cold worked areas, or to the hot strained regions of defects close to welds. It is shown that a suitable heat treatment can restore appreciable ductility to steel embrittled by hot or cold straining. The duration of heating decreases with the temperature, but increases very rapidly with the amount of prestrain. To each temperature corresponds a limiting prestrain for which heat treatment becomes impractically long. Cold strained steel requires considerably longer heat treatment and higher temperatures (1000-1200F) than hot strained steel (700-1000F). Approximate time-temperature-prestrain curves have been experimentally determined. The results confirm that a major beneficial effect of the so-called 'thermal stress-relieving' treatment is a restoration of the ductility of locally embrittled steel. (Author)

Rept. on Manufacture Fundamentals.

Mylonas, C Beaulieu, RJ
Brown University, (SR-158) SSC-167, Apr. 1965, 32p

Contract NObs-88294

ORDER FROM: NTIS

AD-461705

327727
ON EFFECTS OF CARBON AND MANGANESE CONTENT AND OF GRAIN SIZE ON DYNAMIC STRENGTH PROPERTIES OF MILD STEEL

The exceptionally low ductility of mild steel when separated by a rapidly moving crack may be attributed in part to its plastic flow strain-rate sensitivity. The elevation in yield strength under conditions of rapidly rising stress adjacent to the crack tip suppresses formation of the energy-absorbing plastic zone. Variation in composition, particularly of C and Mn content which affect the notched bar impact transition temperature, should also affect strain-rate sensitivity if this description is applicable. The general trends in yield point strain-rate sensitivity are found in agreement with effects of composition on the Charpy transition temperature. A good correlation is found to exist between the parameter k, found from the grain

size dependency of dynamic upper yield strength, and the transition temperature expectancy for given composition. Plastic flow stress, at given high strain rate, can be correlated with free path in ferrite better than with ferrite grain size. (Author)

Krafft, JM Sullivan, AM
Naval Research Laboratory, (SR-142) Final Rpt. SSC-139, Dec. 1961, 36p

Contract NOBs-84321

ORDER FROM: NTIS

AD-269862

327728
ROLLING HISTORY IN RELATION TO THE TOUGHNESS OF SHIP PLATE
Plates of ABS Class-B and Class-C steel were rolled with different temperature-reduction schedules to observe effects of processing history on final structure and properties. Each class was finished at a constant thickness (1-1/2-inch for Class B; 1-1/4-inch for Class C) following both isothermal and non-isothermal schedules with reductions from 15 percent to 60 percent and temperatures in the range 1250F (677C) to 2000F (1093C). The principal measurements for toughness evaluation were the 15 foot-pound V-notch Charpy, the 50 percent-fibrous Charpy, and the tensile-ductility transition temperatures. The superior toughness of Class C at constant grain size was an example of an extra-grain-size effect of composition. Normalizing of Class B plates after rolling produced Widmanstatten structure and some embrittlement which was interpreted as an apparent extra-grain-size effect of this particular heat treatment. Mechanical fibering was studied with techniques that included electron microscopy, but the contribution of microfissuring effects to toughness was too subtle for observation. Embrittlement from residual cold work as a consequence of low-temperature finishing was also identified. Results of heat treatment after rolling were studied in detail. (Author)
Rept. on proj. Mill Rolling Practice.

Kapadia, BM Backofen, WA
Massachusetts Institute of Technology, (SR-147) Final Rpt. SSC-168, May 1965, 55p

Contract NObs-88282

ORDER FROM: NTIS

AD-465025

327729
INTERPRETATIVE REPORT ON WELD-METAL TOUGHNESS
A literature survey was made to review presently available information on the notch toughness of weld metals and the heat-affected zone as they are affected by welding procedures. The base metals discussed in this report include mild steel and low-alloy, high-strength steels with up to 120,000-psi yield strength, such as may be used for merchant-ship construction. Welding processes considered include (1) shielded metal-arc welding, (2) submerged-arc welding, (3) gas metal-arc welding, and (4) electroslag and electrogas welding. One of the most important observations of this literature survey is that relatively limited information is available on the notch toughness of weld metals and heat-affected zones which can be used to establish behavior trends. Information is especially lacking on what constitutes realistic requirements for notch toughness in these zones compared with that of the base metal. It was also observed that relatively little correlation of such factors as chemical composition, microstructure, and welding variables has been made with the notch toughness of weld metals and heat-affected zones. (Author)

Masubuchi, K Monroe, RE Martin, DC
Battelle Memorial Institute, (SR-170) Final Rpt. SSC-169, July 1965, 86p

Contract NOBS-90504

ORDER FROM: NTIS

AD-466805

330974
CLEAVAGE FRACTURE OF SHIP PLATE HATCH CORNER TESTS
Six full scale specimens, similar in design to a hatch corner of a ship, were constructed from a low carbon, ship quality, semi-killed steel and tested to failure. One tested at 120 deg F gave a shear type fracture. All others tested at room temperature failed with cleavage type fractures. Two which were welded with preheat at 400 deg F showed superior performance, both in strength and energy absorption. Two which were fabricated by riveting gave inferior performance. An investigation was conducted to determine the effects of preheat and a comparison made with the effects of 1000 deg F postheat treatment for 8 hours. Studies were made of quarter scale symmetrical and asymmetrical hatch corner models to determine which type of specimen would best duplicate the stress condition existing in actual ships.

DeGarmo, EP Meriam, JL Grassi, RC Harman, JW O'Brien, MP
California University, Berkeley, Ship Structure Committee Prog Rpt. SSC- 1, July 1946, 71p, 3 Ref.

Contract NObs-31222

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AD-636741

330975
CAUSES OF CLEAVAGE FRACTURE IN SHIP PLATE: FLAT PLATE TESTS
The report consists entirely of 37 diagrams of plate elongation measured over various stress levels, 30 photographs of fracture specimens with hardness contours and an appendix. The appendix consists of 67 tables showing percent elongation for each of the wide notched flat plates tested. Readings reproducable to plus or minus .002 inches were taken by means of a special gage prior to loading and after fracture.

Davis, HE Troxell, GE Boodberg, A Parker, ER O'Brien, MP
California University, Berkeley, Ship Structure Committee Prog Rpt. SSC- 2, Aug. 1946, 67p

Contract NObs-31222

ORDER FROM: NTIS

AD-636742

330976
INVESTIGATIONS OF BRITTLE CLEAVAGE FRACTURE OF WELDED FLAT PLATE BY MEANS OF A BEND TEST
Reported herein are the results of several series of bend tests conducted on 10-in. square by 3/4-in. thick plates upon which had been deposited weld metal. The experiments were carried out in conjunction with tests on large welded tubes of ship plate. This report presents a description of the test specimens and the testing technique. Both double-V butt-welded and single-bead specimens were tested as simple beams supported on a 6-in. span, centrally loaded. The weld or bead was so placed that it was stressed in tension by the applied load. Tests were made at various temperatures ranging from room temperature to-40 deg F on specimens welded with E6010 electrodes, low-alloy steel electrodes, 25-20 stainless steel electrodes, and with Unionmelt. The effects on ductility at-40 deg F of preheating to various temperatures ranging from 0 deg F to 500 deg F, of postheating to 1100 deg F, and of normalizing were determined. The effect of arc voltage and the effect of the weld contour on the ductility at various temperatures were determined for E6010 and Unionmelt deposits. Chemical analyses of typical weld deposits were made and the microstructure of most of the specimens was studied, and microhardness surveys were conducted on about half of the specimens tested. Included in the report are the following data: welding conditions, testing temperature, bend angle, maximum elongation, maximum load and type of failure, microstructures, and hardness values. The cracks were found to originate in the weld metal and not in the heat-affected zone of the base plate even though the heat-affected zone was in many cases much harder than the weld metal. The ductility of the bend test specimens was found to be improved by preheating, postheating, low arc-voltage and by the use of stainless steel electrodes. The ductility was decreased by low preheat temperature, low testing temperature, fast rate of electrode travel, high arc voltage, and by the use of electrodes having high hardenability.

Davis, HE Troxell, GE Parker, ER Boodberg, A

California University, Berkeley, Ship Structure Committee Tech Rpt. SSC- 6, Mar. 1948, 111p

Contract NObs-31222

ORDER FROM: NTIS

AD-72181

330977

CORRELATION OF LABORATORY TESTS WITH FULL SCALE SHIP PLATE FRACTURE TESTS: SLOW NOTCH BEND TEST

The present progress report is essentially a continuation of that released March 19, 1947. The objective and outline of work were indicated in that place; the former consisting in the development of a test capable of conduction in the laboratory and which would correlate closely with the large plate test results which were obtained at the University of California and at the University of Illinois. The latter consisting in part in the examination of the Charpy test in the prescribed manner to ascertain if in this test the desired correlation could be obtained. Close correlation was not obtained in this test. In order to obtain the desired correlation, a slow-bend notched-bar test was developed and it is with the results of slow bend testing that this report is concerned.

Gensamer, M Wagner, C Klier, EP
Pennsylvania State University, University Park, Ship Structure Committee Prog Rpt. SSC- 15, Dec. 1947, 25p

Contract NObs-31217

ORDER FROM: NTIS

AD-72679

330978

CORRELATION OF LABORATORY TESTS WITH FULL SCALE SHIP PLATE FRACTURE TESTS

Initially, standard Charpy impact tests were made on all of the steels and the results compared with those for the 72 inch wide plate tests. The comparisons showed that no direct correlation existed between these two widely differing types of notched specimen tests. One of the striking inadequacies of the impact test was the failure to show a difference between steels A and C, a difference which was most pronounced in the 72 inch wide plate tests. Separation of steels A and C to some extent, and in the right direction, was achieved by the use of prestrained Charpy keyhole-notch test bars, but the overall results did not warrant the further use of this test, as the temperatures of tough to brittle transition were too low to use direct correlation procedures. Because of this, a program was initiated in which the effects of specimen size, geometry, and testing velocity on the temperature of transition from tough to brittle behavior were investigated. The results of slow bend testing (at 1 inch per minute) of standard V-notch Charpy impact bars did not separate Steels A and C. The transition temperatures for these two steels were appreciably lowered however, as compared to those obtained from the impact test, and fell in the range of temperatures observed for the large plate test results. An increase in the specimen size to 0.788 inches high x .394 inches wide gave transition temperatures for most of the steels tested which were 10 deg to 20 deg F below those for the 72 inch wide plate tests. Finally, specimens were prepared which were full plate thickness in width and 0.788 inches in height. The tough to brittle transition, as measured by energy absorption values, occurred for these specimens at temperatures which agreed fairly well with the transition ranges for the 72 inch wide plates. Specimens of this type, when tested across a 40 millimeter span, had the disadvantage of not breaking completely. By drilling the compression zone from the specimen and using a hardened steel pin on which to apply the load, as described by Schnadt, it was possible to circumvent this difficulty. The present report is confined to the outline of experiments with this "Schnadt type" specimen and the results pertaining to those experiments.

Wagner, C Klier, EP
Pennsylvania State University, University Park, Ship Structure Committee Prog Rpt. SSC- 18, May 1948, 43p, 5 Ref.

Contract NObs-31217

ORDER FROM: NTIS

AD-71728

330979

EVALUATION OF IMPROVED MATERIALS AND METHODS OF FABRICATION FOR WELDED STEEL SHIPS

This report covers work done during the period June 25, 1947 to February 1, 1948. A survey was made of published and unpublished reports to appraise the various kinds of tests used to study strength, ductility, and transition temperatures of welded joints in structural steels. On the basis of this survey, the Project Advisory Committee selected the tee-bend test, the longitudinally welded and transversely notched bead-bend tests (Kinzel and Lehigh types), and the transversely welded and transversely notched bead-bend tests (Naval Research Laboratory high constraint and Jackson types). These tests were used in a study of steels "B sub r" and "C" and to correlate results obtained with them with results from the hatch corner tests made at the University of California. It was thought that if one of these tests were to give the same transition temperature for B sub r and C steels that the hatch corner did with these steels, then that test would be worthy of further study as a possible acceptance test of steel for ship plate. The studies were made with project steels B sub r and C because they previously exhibited a widely different behavior in the full-scale hatch corner and other tests. Class E6010, 5/32-and 3/16-inch diameter electrodes were used to make the samples for the initial tests. The specimens were tested at various temperature levels to determine the transition temperatures by means of the following criteria: absorbed energy, bend angle, lateral contraction, and fracture appearance. The transition temperatures for the B sub r and C steels showed that all the tests for both welded and unwelded specimens rated the two steels in the same qualitative order as indicated by the hatch corner tests. The variations in the actual transition temperatures were influenced by specimen design, welding conditions, and the various methods of evaluating transition temperature. It was also believed that the oriented discontinuities in the B sub r steel, caused by large elongated complex sulphide inclusions, influenced fracture propagation, and hence the energy absorption, the total bend angle, and the fracture appearance of specimens made from this steel.

Bennett, RW Rieppel, PJ Voldrich, CB
Battelle Memorial Institute, Ship Structure Committee Prog Rpt. SSC-23, Mar. 1949, 51p, 146 Ref.

Contract NObs-45543

ORDER FROM: NTIS

AD-72963

330980

METALLURGICAL QUALITY OF STEELS USED FOR HULL CONSTRUCTION

This is the final progress report on this project and is a continuation of the phase of the investigation discussed in the previous progress report, that is, a study of the influence of chemical composition with the object being to develop a hot-rolled steel with high yield strength and a low level of crack sensitivity that is satisfactory for welded construction. In addition to chemical composition, the results of commercial homogenizing tests are discussed as well as the influence of electrode coatings upon underbead cracking. In order to summarize the work of this project, a final summary report (SSC-26) will be published covering both the results of this investigation and the preceding project on this subject which was conducted for the OSRD as Project NRC-87.

Sims, CE Banta, HM Walters, AL
Battelle Memorial Institute, Ship Structure Committee Final Rpt. SSC-25, May 1949, 92p

Contract NObs-31219

ORDER FROM: NTIS

AD-72961

330981

METALLURGICAL QUALITY OF STEELS USED FOR HULL CONSTRUCTION, FINAL AND SUMMARY REPORT

A study of twenty commercial HTS type steels showed that, in general, the steels with higher chemical composition were the most susceptible to underbead cracking, but frequently the variations in crack sensitivity found in different lots of steel could not be accounted for on the basis of chemical analysis, hardness of the heat-affected zone, hardenability, or the other properties commonly determined. Further study of these commercial steels showed that thermal processing had a pronounced influence upon the

underbead cracking or crack sensitivity, the sensitivity being increased by annealing and decreased by homogenizing. In the case of similar chemical compositions, the level of crack sensitivity was found to increase with the degree of microsegregation. Homogenizing treatments, therefore, which decreased the extent of microsegregation, lowered the crack sensitivity, while annealing, which produced pearlite bands superimposed upon the alloy bands, increased the underbead cracking. Although the crack sensitivity of plate can be reduced to a marked degree by homogenizing at 2350 deg F for a relatively short period, such a treatment is not commercially feasible because of the excessive scaling and warping that would occur to the finished product. Homogenizing the slabs prior to rolling into plate was found to be impractical because of the excessive time required. A good correlation was found between the crack sensitivity and the depth of complete transformation in the heat-affected zone when expressed as per cent of the total depth of the affected zone under the weld bead. The purpose of this investigation, which concerns high-tensile plate steel (HTS type) used in the construction of welded ship hulls, was twofold, the first part being an investigation of the metallurgical quality with special attention being given to those factors which might influence the welding characteristics and the performance of the welded structure. The second part of the project covers the development of higher strength steels suitable for welded structures.

Sims, CE Banta, HM Walters, AL
Battelle Memorial Institute, Ship Structure Committee SSC- 26, June 1949, 115p, 36 Ref.

Contract NObs-31219

ORDER FROM: NTIS

AD-72962

330982
CAUSES OF CLEAVAGE FRACTURE IN SHIP PLATE, TESTS OF RESTRAINED WELDED SPECIMENS AND HATCH CORNER SPECIMENS OF MILD STEEL

This report summarizes the results of a series of tests conducted as a supplementary program to the research investigation that was carried out on the behavior of high yield strength structural steels under the U. S. Navy Research Contract NObs-31222. The main objective of this auxiliary program was to provide a basis for comparison of results from the high yield strength structural steels and the extensive results that were obtained in the numerous investigations conducted on the ship quality mild steels. The temperatures at which the mode of fracture changed from shear to cleavage type were determined for two of the mild steels by means of tests on several types of specimens. Several widely different types of specimens were used in this investigation. The first type of specimen was made in two different sizes but with the same thickness of steel plate. They were made to provide restraint to plastic flow at a corner produced by welding together steel plates set along three mutually perpendicular planes. Other speciments were in the form of simple notched plates of different sizes. Also, tensile tests were made on 3/4-inch thick flat plate specimens. Some of these contained welds only along their longitudinal axes while others had both transverse and longitudinal welds. The results of the tests on the two sizes of large restrained welded specimens indicated that the width and height of this type of specimen apparently had little or no effect on the transition temperature. The results of the tests performed on notched plate specimens showed that the transition temperatures determined by tests of the two sizes of this type of specimen were in good agreement with each other, but that the transition temperatures as determined by notched plate tests were considerably lower than those obtained with large restrained welded specimen tests. Tension tests of simple welded flat plate specimens indicated that the transition temperatures of the steels were not materially affected by the introduction of a single longitudinal weld along the loading axis or by the presence of two intersecting welds at the center of the unnotched plate specimen.

Boodberg, A Parker, ER
California University, Berkeley, Ship Structure Committee Prog Rpt. SSC- 27, Aug. 1949, 33p, 6 Ref.

Contract NObs-31222

ORDER FROM NTIS

AD-635795

330983
APPLICATION OF THE EXPLOSIVE TEST TO EVALUATE SHOCK PROPERTIES OF HIGH YIELD STRENGTH STEELS

Resul's of a preliminary investigation to establish optimum technique for direct-explosion testing of high yield strength steels has been undertaken. Optimum test-plate size, method of supporting test plate, and type of explosive required have been established. A theoretical study of the state of stress exisiting in test plates was made.

Muller, A Benz, WG Snelling, WH
Air Reduction Company, Incorporated, Ship Structure Committee Final Rpt. SSC- 29, July 1949, 26p

Contract NObs-34232

ORDER FROM: NTIS

AD-134709

330984
CORRELATION OF LABORATORY TESTS WITH FULL SCALE SHIP PLATE FRACTURE TESTS

The role of materials in the ship fracture problem is obvious. If such materials were not susceptible to brittle failure, the problem would cease to exist. With the objective of a final evaluation of weldable steels as to their suitability for merchant vessel construction, a wide experimental program was initiated by the Board of Investigation to Inquire into the Design and Methods of Construction of Welded Steel Merchant Vessels and continued by the Ship Structure Committee. It was the objective of the research program conducted at the Pennsylvania State College under Bureau of Ships Contract NObs-31217 to correlate the work conducted for the Board and the Ship Structure Committee. This final report attempts, therefore, the correlation of the results of the entire "material" research program as conducted between 1944 and approximately the end of 1950.

Klier, EP Gensamer, M
Maryland University, College Park, Columbia University, New York, Ship Structure Committee Final Rpt. SSC- 30, Jan. 1953, 45p, 34 Ref.

Contract NObs-31217

ORDER FROM: NTIS

AD-8710

330985
HIGH SPEED ROTATING DISK PROJECT

The general objectives of this experimental program were (1) to develop a suitably supported solid disk type specimen, having no disturbing central nib, which would permit unrestrained plastic expansion under high rotation at speeds up to bursting, (2) to measure the strain patterns at several stages of flow up to bursting on specimens of this type to disclose the basic mechanism of flow and provide a means of calculating bursting stresses and (3) to make low-temperature tests on full-size disks of this type to determine the transition temperature from ductile to brittle fracture. Since parts (2) and (3) depend directly on part (1), this was first attacked. Various designs were tried in order to perfect such a specimen. Several attempts were successful in carrying a special flange-supported type specimen containing no central nib well up into the plastic range; up to the present it has not been possible to develop one which could be carried successfully to bursting. Since most of the time was thus utilized for part (1) of the program, only a limited amount of data was accumulated for (2). Some of the necessary equipment for part (3) was either designed or acquired but no tests were conducted for the reasons explained above.

MacGregor, CW Tierney, WD Majors, H, Jr
Massachusetts Institute of Technology, Ship Structure Committee Final Rpt. SSC- 32, Aug. 1949, 40p

Contract NObs-46302

ORDER FROM: NTIS

AD-134702

330986
EVALUATION OF IMPROVED MATERIALS AND METHODS OF FABRICATION FOR WELDED STEEL SHIPS

This report covers the work done during the period January 1, 1949, to June 30, 1949. On the basis of the discussion of the work reported in the second

progress report, SSC-33, the Project Advisory Committee recommended that the behavior of two additional project steels, "A" and "W" should be determined at various temperatures (200 F to-100 F) using the Kinzel-type specimen. It was also decided that a study would be made to determine the effect of preheat and postheat treatments on the behavior of "B sub r" and "C" steels when tested at various temperatures (200 F to-100 F) using the Kinzel specimen. Tests using the Kinzel specimen to determine the transition-temperature range of "A" and "W" steels rate these two steels in the same order that all the other type specimens have done. The four steels which have now been rated with the welded Kinzel specimen have the following order of increasing transition-temperature range: "B sub r", "W", "A", and "C". When tested with Kinzel specimens, but without the weld beads, "B sub r", "W" and "A" behaved very much alike, while "C" had a considerably higher transition-temperature range. The studies on the effect of preheat and postheat on welded Kinzel specimens of "B sub r" and "C" steels revealed tht the "B sub r" steel responded more than "C" steel to the use of preheat. As the preheat was raised, the transition-temperature ranges for both steels were lowered. A postheat treatment improved the amount of energy absorbed by both steels at low temperatures. Vickers hardness serveys of Kinzel specimens of "B sub r" and "C" steels welded at various preheats were made. In the specimens of "B sub r" steel, the weld metal was harder than the heat-affected zone, while the reverse was true for the "C" steel. Both preheat and a high temperature postheat each reduced hardness in both the weld metal and the heat-affected zone.

Baysinger, FR Kline, RG Rieppel, PJ Voldrich, CB
Battelle Memorial Institute, Ship Structure Committee Prog Rpt. SSC-36, Dec. 1950, 41p, 7 Ref.

Contract NObs-45543

ORDER FROM NTIS

AD-73103

330987
WELDED HATCH CORNER DESIGN

The purpose of this report is to assemble and summarize such portions of the available information relating to hatch corner failures and tests as are significant in the actual design of a welded hatch corner for a typical cargo vessel. Attention will be paid principally to the matter of the geometry and size of the structure. For this reason such factors as temperature, notch sensitivity of the material, and strain rate, which are known to be contributory causes of failures are not discussed. The hatch corners particularly referred to in the report are those on the weather deck of a cargo vessel and located in the mid-ship 3/5 length. The design principles given here apply also to corners located elsewhere but to a lesser degree. It is not to be considered that this report presents the final word with reference to hatch corner design. It represents merely the best advice that can be given at the present time, based on the available Ship Structure Committee data on this subject.

Ship Structure Committee (Project SR-117)
SSC- 37, Oct. 1952, 15p, 3 Ref.

ORDER FROM NTIS

AD-29400

330988
A STUDY OF PLASTIC DEFORMATION AND FRACTURING BY STRAIN ENERGY DISTRIBUTION

This investigation was conducted to study the plastic deformation and fracturing of 12 inch wide, 3/4 inch thick internally notched steel plates under axial tension by determining the strain energy distribution on the surface of the deformed regions of the plates. Several stages in the process of deformation and fracturing at 70 deg F and 10 deg F were investigated to maximum load, 70 deg F being above the transition temperature, and 10 deg F being below the transition temperature. Surface strain energy distribution across the crack was also determined for a specimen fractured ductilely at 70 deg F. By using the octahedral theory in connection with the assumption of incompressibility and the assumption that the principal coordinate system is parallel to the three dimensions of the plate, the unit energies on the surface of the plate were obtained from grid measurements. By assuming that the energy distribution is independent of the thickness dimension. Total energy is obtained for comparison with the total energy input measured from the load-elongation curve. The results of this investigation show that the total energy based on octahedral theory and the above-stated assumptions agrees very well with the total observed energy input; that the rate of propagation of plastic deformation with respect to energy input decreases with decreasing temperature; that, for specimens with two dimensional similarity and constant thickness, the total energy of individual specimens of varying width can be predicted by the strain energy distribution of a single specimen of proper width; and that, at room temperature, the unit strain energy at the crack is found to be approximately in the order of 30,000 in-lbs per cubic inch in a ductile specimen.

Liu, SI Carpenter, SI
Swarthmore College, Ship Structure Committee Prog Rpt SSC- 38, Dec. 1950, 37p, 5 Ref.

Contract NObs-45521

ORDER FROM NTIS

AD-635785

330989
WELDED REINFORCEMENT OF OPENINGS IN STRUCTURAL STEEL MEMBERS

The experimental investigation reported herein had as its purpose the determination of the effectiveness of four types of arc-welded reinforcement for openings in plain-carbon structural steel plates loaded under uniform tension. The opening was centrally located in each plate and had a width equal to one-fourth of the width of the plate. The effect of the opening and of the various types of reinforcement upon the load at yielding, the ultimate strength, the ductility, and the unit strain distribution in the vicinity of the opening was investigated and compared with similar observations for plates without openings. The test program covered in this report is the initial part of a larger program of tests. Included in the present report are tests at room temperature of two plain plates without openings, three plates with unreinforced openings, and eighteen plates with arc-welded reinforcement around the opening. Three types of welded reinforcement were investigated: face bars, single doubler plates, and insert plates. The plates without reinforcement and those with each type of reinforcement were fabricated with three different shapes of openings: circular, square with rounded corners, and square with sharp corners.

Vasarhelyi, D Hechtman, RA
Washington University, Seattle, Ship Structure Committee Prog Rpt. SSC- 39, Dec. 1951, 103p, 32 Ref.

Contract NObs-50238

ORDER FROM NTIS

AD-72097

330990
EVALUATION OF IMPROVED MATERIALS AND METHODS OF FABRICATION FOR WELDED STEEL SHIPS

This report covers work done during the period of July 1, 1949, to October 15, 1950. This program was requested by the Project Committee and the Committee on Ship Steel to secure a true appraisal of the notched-bead bend test as a test for evaluating performance of ship steels in large welded structures. It was thought that a determination of the fracture mechanism should accomplish this by showing if welding makes the steel in the heat-affected zone of the weld more susceptible to brittle failure or if some feature of the fracture process makes the test unsuited to that purpose. This investigation coves crack initiation and propagation in Kinzel-type specimens made from "Br" and "C" steels. It also covers miscellaneous studies of fracture in Lehigh specimens; in special Kinzel-type specimens taken from "C" steel weldments of the kind being investigated by Case Institute of Technology (SSC Project SR-99), and specimens of a steel containing 0.33 per cent carbon and 0.88 per cent manganese

Baysinger, FR Kline, RG Rieppel, PJ Voldrich, CB
Battelle Memorial Institute, Ship Structure Committee Prog Rpt SSC-40, Oct 1951, 59p, 12 Ref

Contract NObs-48015

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AD-73101

330991
EVALUATION OF IMPROVED MATERIALS AND METHODS OF FABRICATION FOR WELDED STEEL SHIPS

This is the fifth progress report on the investigation entitled, "Evaluation of Improved Materials and Methods of Fabrication for Welded Steel Ships", being conducted for the Ship Structure Committee (Project SR-100). The first objective of this phase of the investigation was to determine the underbead cracking tendencies of forty-one heats of ABS Class "B" and "C" hull steels using the Battelle underbead cracking test. The second objective was to determine whether the more crack-sensitive heats would give trouble in service, as measured by large tee-joint specimens which simulated ship welding conditions. This report describes the details of the crack-sensitivity studies, the tee-joint tests, and the supplemental studies which were conducted.

Baysinger, FR Kline, RG Rieppel, PJ Voldrich, CB
Battelle Memorial Institute, Ship Structure Committee Prog Rpt. SSC-41, Oct. 1951, 46p, 3 Ref.

Contract NObs-50148

ORDER FROM: NTIS

AD-73102

330992
THE DETERMINATION OF INITIAL STRESSES IN STEEL PLATES

A non-destructive method for the determination of the direction and magnitude of the principal stresses at any location in a structure, such as a ship or a bridge, has been investigated and developed as reported here, in an effort to overcome the generally destructive and costly methods presently available. This non-destructive method consists of attaching electric-wire strain gages around the point at which the stress is to be measured and then drilling a hole (1-1/8 in. to 1 in. diameter) at that point. The gage reading before and after the drilling of the hole are used to determine the stress. Known stress values up to 15,000 psi were applied to test plates, and measurements were made by the hole relaxation method. When corrected for the stresses initially contained in the plates, this hole relaxation method checked the known applied stresses to within 1000 psi. The holes are easily and economically repaired.

Riparbelli, C Suppiger, EW Ward, ER
Princeton University, Ship Structure Committee Final Rpt. SSC- 42, Sept. 1958, 48p, 7 Ref.

Contract NObs-47613

ORDER FROM NTIS

AD-218860

330993
EVALUATION OF IMPROVED MATERIALS AND METHODS OF FABRICATION FOR WELDED STEEL SHIPS

Work done toward finding a test for evaluating steels for large welded structures started with a literature survey of tests used previously to study the qualities of welds in steel and the weldability of steels. From the results of the survey, five types of tests which seemed most promising for further study were selected. Of the five types of tests selected and studied, the Kinzel test using notched weld-bead specimen was used for the major part of the work, particularly to determine the transition-temperature ranges of project steels "Br", "C", "A", and "W" and to deter the micromechanism of fracture initiation and propagation as a guide to the interpretation of the results. At the start, a premise was set up for this investigation that, if the transition-temperature range which had previously been determined for the full-scale hatch-corner specimen was matched by that of a small specimen of the same steels, the small specimen would be useful in predicting the performance of steels in large welded structures in general. To this end, various modifications were made in the design of the Kinzel-type specimen and in testing procedure. A detailed study was made of crack initiation and propagation in Kinzel-type specimens to obtain fundamental information on factors contributing to the performance of the test. It was also desired to determine why welded Kinzel-type specimens always gave poorer performance than unwelded Kinzel-type specimens of the same steels. On the third objective, work included a study of forty-one heats of ABS Classes B and C steels using the Battelle underbead cracking test. Nine of these steels were used in large tee joints designed to simulate ship-welding conditons. The effects of various test modifications on cracking in these tee joints were studied.

Baysinger, FR Rieppel, PJ Voldrich, CB
Battelle Memorial Institute, Ship Structure Committee Final Rpt. SSC-45, Dec. 1951, 30p

Contract NObs-48015

ORDER FROM: NTIS

AD-494774

330994
EVALUATION OF SHIP WELDING PROCEDURES BY DIRECT EXPLOSION TESTING

The investigation described in this report is a direct continuation of work described in report SSC-43. The Ship Structure Committee directed further exploration of the relative effects of different welding procedures on the notch toughness of the welded joint as determined by the direct explosion test as follows: 1) Determine notch toughness of welded joints of a semi-killed and of a fully killed steel when welded with: a) Class E-7016 electrodes, and b) Submerged arc process, using two passes, one from each side. 2) Obtain a general indication of the relative effects on the notch toughness of welded joints of a fully killed steel, of the following factors: a) preheat of 150 deg F, b) interpass temperature, c) low temperature stress relief, and d) peening of all weld passes.

Mikhalapov, GS
Metallurgical Research and Development Company, Ship Structure Committee Final Rpt. SSC- 46, Aug. 1951, 17p

Contract NObs-53383

ORDER FROM NTIS

AD-72118

330995
THE STRENGTH, ENERGY ABSORPTION AND TRANSITION TEMPERATURE OF INTERNALLY NOTCHED FLAT STEEL PLATES

This is a final report presenting the results of an extended series of tests made mainly to determine the effects of temperature upon strength, energy absorption and transition temperature of ship plate steels in tension specimens of "wide plate" type with standardized internal notches. The report is presented in three parts, the first part dealing with 12 inch wide by 3/4 inch thick specimens. Most of the steels used were the so-called pedigreed steels. The second part of the report deals with geometrically similar internally notched steel plates of variable width and thickness. The objective of these tests was to separately determine the metallurgical and geometrical effects of plate thickness. All plates were tested in "as rolled" thickness. The third part of the report concerns detailed studies to determine the energy distribution in 12 inch wide internally notched plates. Unit strain energy was computed using surface strains obtained by grid measurements.

Swarthmore College, Ship Structure Committee Final Rpt. SSC- 47, Jan 1953, 86p, 14 Ref.

Contract NObs-45521

ORDER FROM NTIS

AD-29340

330996
WELDED REINFORCEMENT OF OPENINGS IN STRUCTURAL STEEL MEMBERS: A DETERMINATION OF STRAIN ENERGY DISTRIBUTION AND TRUE STRESSES IN THE PLASTIC RANGE IN PLATES WITH OPENINGS

The research reported herein is a part of the investigation of welded reinforcement of openings in structural steel members. A previous report described the tests of 1/4-in. plates with and without welded reinforcement. The purpose of the tests covered by this report was to determine the unit strain energy and the true stress distribution in the plastic range of the material in a flat plate with a centrally located opening, which was square with rounded corners. Two such plates made from plain-carbon semi-killed structural steel were tested in tension, one at room temperature and the other at a temperature of minus 20 Deg. F. The octahedral theory was used to determine the unit strain energy distribution, while the true stresses were

computed by a method developed in the course of the investigation. Both types of analyses utilized the experimental data of the tests as the basis of the computations. It was impossible to check the unit strain energy and true stress distributions directly, but when these were integrated in a specified manner, the total energy absorption and the load on cross-sections of the plate were obtained. These, when compared with the experimentally determined values of total energy absorption at different loads and with the testing machine load at the ultimate load gave reasonably good checks.

Vasarhelyi, D Hechtman, RA
Washington University, Seattle, Ship Structure Committee Prog Rpt. SSC- 50, Mar. 1952, 26p

Contract NObs-50238

ORDER FROM: NTIS

AD-73011

330997
THE LOW TEMPERATURE PROPERTIES OF RELATIVELY HIGH PURITY IRON-CARBON ALLOYS
The onset of brittleness in ship steel plate at a temperature which is determined by metallurgical and mechanical factors, continues to be a technical problem of considerable importance. Previous investigations of the metallurgical and mechanical factors have generally been on material equivalent to that used in actual practice; i.e. material containing a large number of compositional and stress variables. The present investigation, attempting to eliminate most of these variables, involved uniaxial tensile testing of eight relatively high purity alloys of iron containing from 0.020% to 0.49% carbon, stressed at temperatures from 28 deg C to those of liquid air or about-185 deg C. The structural conditions such as ferrite grain size and pearlite spacing were fixed and the strain rate was generally constant. The form of testing gave true stress-natural strain data. This made possible numerical evaluation of many parameters such as yield points, flow stresses, fracture stresses, ductilities in terms both of uniform and localized deformation and strain hardening factors. All of these were determined as affected by carbon content, and by temperature.

Smith, RL Fostini, RV Brick, RM
Pennsylvania University, Philadelphia, Ship Structure Committee Prog Rpt. SSC- 52, Aug. 1952, 56p

Contract NObs-50062

ORDER FROM: NTIS

AD-8781

330998
THE FUNDAMENTAL FACTORS INFLUENCING THE BEHAVIOR OF WELDED STRUCTURES UNDER CONDITIONS OF MULTIAXIAL STRESS AND VARIATIONS OF TEMPERATURE
The eccentric notch tensile test previously employed in exploring the relative ductility at the midthickness level of A and C steel weldments has been applied to an evaluation of the ductility at the surface level and at various positions in the weld metal of a C steel weldment. The surface tests at various low temperatures located a zone of low ductility at a distance of 0.4 inch from the weld centerline of 3/4 inch plate. This zone was outside the so-called heat affected zone and appeared to have the same metallographic structure as the base plate. These findings are in agreement with those previously reported at the midthickness level of both A and C steel weldments. Low temperature probe tests in the weld metal failed to detect any zones of low ductility. In addition, data are presented comparing the notched (eccentric and concentric) and unnotched tensile properties at the midthickness level of an A steel weldment. Various low temperature tests revealed that the concentric notch ductility varied across the welded plate in the same manner as the eccentric notch strength, thus confirming that the eccentric notch strength is a measure of notch ductility. In contrast, the variation in concentric notch strength and unnotched tensile properties across the welded plate failed to detect zones of low ductility in the subcritically heated plate. A comparison with other investigations of welded plate indicates that the eccentric notch tensile test is not unique in defining a region of minimum ductility in the subcritically heated parent plate and that this region may play an important role in the fracture behavior of welded plate.

Evans, EB Klingler, LJ
Case Western Reserve University, Ship Structure Committee Prog Rpt. SSC- 54, Oct. 1952, 42p, 36 Ref.

Contract NObs-45470

ORDER FROM: NTIS

AD-73035

330999
WELDED REINFORCEMENT OF OPENINGS IN STRUCTURAL STEEL MEMBERS: ROOM AND LOW TEMPERATURE TESTS OF PLATES WITH REINFORCED OPENINGS
This report continues the work in which the investigation of various room temperature properties of selected types of arc-welded reinforcement for openings in plain-carbon structural steel plates loaded under uniform tension led to the conclusion that from the standpoint of performance the square opening with rounded corners having a 1-1/8-in. radius and the circular opening appeared to give the best properties. Since this investigation covered only the behavior of specimens at room temperature, the problem of their behavior in the more critical low temperature range was unknown. Moreover, it was desirable to parallel the previous tests of 36-in. by 1/4-in. plates with tests of 48-in. by 1/2-in. plates in order to use thicker plate which would have a higher transition temperature. This progress report includes tests of four specimens 36 in. by 1/4 in. and nine specimens 48 in. by 1/2 in. in cross-section, four of the former and four of the latter being tested at low temperatures. All specimens had a 9-in. by 9-in. square opening with rounded corners reinforced by a welded face bar, single doubler plate, or insert plate. The strength characteristics, the unit strain distribution and concentration in the vicinity of the opening, and the total energy absorption were studied for all specimens. The results of the low temperature tests were compared with those obtained in the room temperature tests. Another phase of this research investigated the distribution of unit strain energy and stress in the plastic range of the material.

Vasarhelyi, D Hechtman, RA
Washington University, Seattle, Ship Structure Committee Prog Rpt. SSC- 55, June 1953, 66p

Contract NObs-50238

ORDER FROM: NTIS

AD-29401

331000
WELDED REINFORCEMENT OF OPENINGS IN STRUCTURAL STEEL MEMBERS: CLEAVAGE FRACTURE AND PLASTIC FLOW IN STRUCTURAL STEEL PLATES WITH OPENINGS
The study of welded reinforcement of openings in structural steel plates has as an objective the development of better design specifications. A thorough investigation of the plastic behavior of the plates was deemed necessary as a phase of this project. This avenue of approach led to energy and stress studies which utilized experimental techniques and theoretical concepts whose applicability had to be verified. The Second Progress Report presented the first results thus obtained, which were sufficiently encouraging to justify the continuation of this type of analysis. It dealt only with notched plates without reinforcement. The present Fourth Progress Report broadens the subject, including more theoretical and basic data on one hand and the application of the methods of plastic analysis to reinforced plates on the other. It covers the tests of an unreinforced plate with a circular opening, two unreinforced plates with a square opening, and two plates with a reinforced square opening with rounded corners. The methods of plastic analysis previously applied to unreinforced plates gave satisfactory results for reinforced plates. The test results of two plates with a square opening with rounded corners from the Second Report are included where direct comparison is necessary.

Vasarhelyi, D Hechtman, RA Yoshimi, YT
Washington University, Seattle, Ship Structure Committee Prog Rpt. SSC- 56, Mar. 1954, 67p, 9 Ref.

Contract NObs-50238

ORDER FROM NTIS

AD-73015

331001
CRACKING OF SIMPLE STRUCTURAL GEOMETRIES: INVESTIGATION OF WELDED SHIP DETAILS

This progress report presents the results of an investigation of the effect of geometry on strength and transition temperature of certain structural details found in welded ships. The detail geometries investigated were those which are currently used in ship structural design, or certain proposed modifications to existing design. These include the structural geometries found at the ends of welded, free ended stiffeners and longitudinals, and the transition details between the sheer strake and fashion plate. The specimens were of 3/4-inch thick project steel DN or ABS class B steel. For the tests in which free end stiffeners and longitudinals were involved, variations in the contour of the free end were investigated. It was found that cutting the end of a stiffener or a longitudinal to a radius was definitely beneficial. The chief benefits were in the lowering of transition temperature when the ends of these structural members were cut back from a square ended condition. Strength was not affected to any critical extent by varying the end geometry. The results emphsize the importance of avoiding abrupt structural transitions from one component to another. As smooth a transition as may be practicable gives the best results.

Carpenter, ST Linsenmeyer, RF
Swarthmore College, Ship Structure Committee Prog Rpt. SSC- 57, June 1953, 57p, 3 Ref.

Contract NObs-50250

ORDER FROM: NTIS

AD-29403

331002
LOW TEMPERATURE EMBRITTLEMENT MECHANICS DEDUCED FROM ZINC SINGLE CRYSTAL FRACTURE STUDIES

The most important conclusion of this work is that low temperature brittleness in zinc single crystals is not due to the cessation of slip below a certain temperature. On the contrary slip is quite active, and it is its activity that induces low temperature brittleness: slip causes rotation of the lattice which in turn sets up orientation gradients adjacent to constricted and unslipped regions. At high temperatures these orientation gradients are accommodated by kink-planes, at low temperatures, by cleavage. These observations are important, for they bear directly on the problem of low temperature brittleness of polycrystalline zinc (because of the orientation gradients always found in polycrystalline metals when deformed) and on the reasons for the lack of low temperature brittleness in face-centered cubic metals (which kink differently from hexagonal close packed crystals).

Morton, PH Baldwin, WM, Jr
Case Western Reserve University, Ship Structure Committee Prog Rpt. SSC- 58, May 1953, 51p, 13 Ref.

Contract NObs-50303

ORDER FROM: NTIS

AD-29766

331003
CRITICAL STRESS FOR SLIP, TWINNING, AND CLEAVAGE IN SINGLE CRYSTALS OF IRON

The objectives of this investigation reported herein are as follows: (1) To produce a ferrite of nominal purity from SAE 1008 steel; (2) To grow single crystals of this material of a size suitable for subsequent tension tests; (3) To find the critical resolved shear stresses for slip and twinning insofar as they can be determined as a function of temperature; (4) To determine whether a transition from slip to twinning occurs with reproducibility of results and whether a criterion for the onset of twinning can be established; (5) To study the fracture properties of single crystals as a function of temperature, strain, aging, and prestrain. (6) To investigate the atomic nature of slip in iron by methods of higher resolving power, e.g., a. The electron microscope. b. Multiple beam interferometry and (7) To correlate the above in a general theory of deformation for lambda-iron.

Cox, JJ, Jr Horne, GT Mehl, RF
Carnegie-Mellon University, Ship Structure Committee Prog Rpt. SSC-59, May 1953, 45p, 14 Ref.

Contract NObs-50230

ORDER FROM: NTIS

AD-29769

331004
THE FUNDAMENTAL FACTORS INFLUENCING THE BEHAVIOR OF WELDED STRUCTURES: THE EFFECT OF SUBCRITICAL HEAT TREATMENT ON THE TRANSITION TEMPERATURE OF A LOW CARBON SHIP PLATE STEEL AND SUPPLEMENT ON EMBRITTLEMENT OF "C" STEEL BY NITROGEN

The dependence of transition temperature upon subcritical heat treatment has been investigated in a low carbon ship plate steel (Project Steel "C"). The effect of time at temperature in the 700 deg--1200 deg F range has been determined, employing three different cooling rates--air cool, furnace cool, water quench. In addition, a limited study was made of the room temperature and the accelerated aging effects after water quenching from 1200 deg F. The degree of embrittlement was evaluated by means of eccentric notch tensile and Charpy V-notch impact tests, with the as-received plate as a basis of comparison. No change in microstructure could be noted between the subcritically treated specimens and the as-received plate with these exceptions: (1) a general precipitation was evident after accelerated aging, and (2) slight spheroidization was apparent at the long isothermal times. Rockwell B hardness tests showed that, in general, appreciable hardening occurred when specimens were embrittled. Previous work on welded plate showed that the necessary conditions for quench-aging are present in the welded material and this phenomenon appears to be the only possible explanation for the zone of minimum ductility located in a region adjacent to the weld which was not heated above the lower critical temperature. Cooling rate curves are presented for the critical zone in weldments made with various preheat temperatures to show that not only does the embrittlement increase with increasing cooling rate, but that the degree of embrittlement is about the same for the critical zone in weldments as for subcritically heat treated base plate cooled at the same rate from the same temperature.

Evans, EB Klingler, LJ
Case Western Reserve University, Ship Structure Committee Prog Rpt. SSC- 60, Oct. 1953, 87 p., 6 Ref.

Contract NObs-45470

ORDER FROM: NTIS

AD-29767

331005
THE FUNDAMENTAL FACTORS INFLUENCING THE BEHAVIOR OF WELDED STRUCTURES: THE EFFECT OF SUBCRITICAL HEAT TREATMENT ON THE TRANSITION TEMPERATURE OF A LOW CARBON SHIP PLATE STEEL

An investigation was made to determine the impact transition temperature and hardness changes attendant to the quench-aging of Project Steel "C" a semi-killed ship plate steel. Aging temperatures extended over the range from 35 deg to 1100 deg F after water quenching from 1300 deg F. Both impact and hardness tests revealed that this steel can be severely embrittled by the quench-aging mechanism. With aging temperatures up to 350 deg F, characteristic aging curves were obtained, i.e., the peak embrittlement and the time to attain this peak decreased with increasing aging temperature. For room temperature aging this peak amounted to a 90 deg F increase in transition temperature and 25 points increase in Rockwell B hardness above that of a series air cooled from 1300 deg F (unembrittled condition). Specimens aged above 350 deg F "overaged" so rapidly tht no peak in the aging curve could be detected. Metallographic examination of quench-aged specimens at 2000X showed that a two-stage precipitation reaction was operative. At low aging temperatures the precipitate was detected as a mottling of the ferrite grains; at higher aging temperatures, where an "overaged" condition was rapidly reached, the precipitate had grown so as to be resolvable. It is believed that the quench-aging phenomenon is responsible for the brittle zone previously found in the subcritically heated region in weldments of this and similar ship plate steels. This study suggests that a low temperature postheat at 650 deg F (the solution temperature below which quench-aging effects are absent) would lead to rapid overaging in the brittle zone of ship plate weldments and thus largely eliminate the embrittlement.

Evans, EB Garibotti, DJ
Case Western Reserve University, Ship Structure Committee Prog Rpt. SSC- 61, Oct. 1953, 25p, 7 Ref.

Contract NObs-45470

ORDER FROM: NTIS

AD-29768

331006
PAST STRUCTURAL STUDIES RELATED TO THE SHIP AND SHIP COMPONENTS AND FOR DETERMINING LOADS AND STRAINS ON SHIPS AT SEA
(1) Basic heart of plate stress distribution across a ship cross section complies well with simple beam theory but with local deviations sometimes evident in such locations as fore and aft stiffner attachments to plating. (2) While both riveted and welded ships experience occasional structural difficulties, they have been more numerous and severe in welded ships. In welded vessels cracks appeared both to initiate and to propagate more readily. (3) Poor welding workmanship, poor design details, inadequate material or physical and metallurgical notches do not appear to satisfactorily provide the full explanation of welded ship failures. (4) Plating panels which are unfair in the unloaded condition of the ship are more prevalent in welded construction than in riveted. When loaded, the stress sustained by such panels depart from the stress distribution predicted by the simple beam theory and cause a lack of uniformity of stress that may contribute to crack initiation and crack propagation. (5) A means of estimating ship bending moments making possible more precise evaluation of the variable dynamic nature of the loading is desirable. Shock loading design criteria are particularly necessary.

Evans, JH Jaeger, HE Verbeek, HA Turnbull, J
Massachusetts Institute of Technology, Ship Structure Committee SSC-62, Dec. 1953, 65p

Contract NObs-50148

ORDER FROM: NTIS

AD-73876

331007
WELDED SHIP FAILURES
The purpose of this report is to review critically the available information on structural failures in welded ships. Although buckling failures in a few naval vessels and several transversely framed European tankers have been reported, this report will review failures from the brittle fracture point of view.

Acker, HG
Bethlehem Steel Corporation, Ship Structure Committee SSC- 63, Dec. 1953, 58p, 23 Ref.

Contract NObs-50148

ORDER FROM: NTIS

AD-73901

331008
PART I: THE FUNDAMENTAL FACTORS INFLUENCING THE BEHAVIOR OF WELDED STRUCTURES UNDER CONDITIONS OF MULTIAXIAL STRESS AND VARIATIONS OF TEMPERATURE PART II: THE EFFECT OF SUBCRITICAL HEAT TREATMENT ON THE TRANSITION TEMPERATURE OF A LOW CARBON SHIP PLATE STEEL
Three progress reports were issued entitled, "The Fundamental Factors Influencing the Behavior of Welded Structures under Conditions of Multiaxial Stress, and Variations of Temperature, Stress Concentration, and Rates of Strain". The major objectives were to determine the relative notch toughness of various zones in commercially welded ship plate steel, and, if such zones could be isolated to determine the dependence of the notch behavior upon material, variations in the welding process, and heat treatment. Eccentric notch tensile tests at various low temperatures were used to evaluate the ductility of a small volume of metal from any position in the weldment. A summary of the work toward these objectives is presented in Part I of this report. Two progress reports were submitted under the title, "The Effect of Subcritical Heat Treatment on the Transition Temperature of a Low Carbon Ship Plate Steel". The principal objectives were to (1) give an insight into the basic mechanism which was responsible for the brittle zone found in the subcritically heated region in weldments; (2) determine the maximum embrittlement possible in base plate by subcritical heat treatment; and (3) suggest possible methods of minimizing or eliminating this embrittlement in base plate which may be applicable to weldments. This work is presented in Part II. The important findings of the two different phases of the investigation are integrated to show that the quench-aging mechanism appears to be responsible for the brittle zone outside the weld area of low carbon ship plate weldments.

Baldwin, WM, Jr Evans, EB
Case Western Reserve University, Ship Structure Committee Final Rpt. SSC- 64, Nov. 1953, 48p, 8 Ref.

Contract NObs-45470

ORDER FROM: NTIS

AD-73867

331009
CRITICAL STRESSES FOR SLIP, TWINNING, AND CLEAVAGE IN SINGLE CRYSTALS OF IRON
An X-Ray, optical and metallographic study of the stresses for--and mechanisms of--slip, twinning and fracture in single crystals of iron prepared from decarburized mild steel has been made. The selection of the glide ellipse has been found to be a function of the relative difficulty of atom motions at various positions along a (111); this function being affected by temperature and distribution of stress. A critical shear stress criterion applies. Twinning has been found to occur on (112) type planes and in (111) directions below-170 deg C. as predicted by a critical shear stress law, mutatis mutandis. The twinning stress is greatly affected by slip. Brittle fracture could be accounted for by a critical normal stress theory within wide limits of error. Ductile fractures predominated for specimens where a cleavage plane, (001), was more than 65 degrees axis. Various effects of prestraining were observed.

Cox, JJ, Jr
Carnegie-Mellon University, Ship Structure Committee Final Rpt. SSC-66, Feb. 1954, 141p, 39 Ref.

Contract NObs-50230

ORDER FROM: NTIS

AD-78998

331010
MODEL TESTS ON HULL-DECKHOUSE INTERACTION
The purpose is to check a theory and formula proposed by H.H. Bleich on stress relationship of hull and house for vessels fitted with long deckhouses. The theory is based on the concept of separate house and hull bending with interaction strongly dependent upon vertical stiffness of support of house. Nine tests were performed upon a single 20-ft. aluminum model with three separate houses, fitted for simple variation of underdeck stiffness. The hull of double-cell construction, connected by fitted bolts and high-torque bolts with houses 160 and 80 in. in length and demountable main deck equipped with simulated deck beams. Design based upon proportionality of elastic action of ships and model with midship proportions in general conformance with passenger vessel practice. Range of Bleich u value for nine tests representative of ship values to be expected. Model loaded to give constant hogging moment throughout length of house.

Crawford, L Ruby, WJ
Reed Research Incorporated, Ship Structure Committee Final Rpt. SSC-67, Jan. 1955, 143p, 9 Ref.

Contract NObs-54509

ORDER FROM: NTIS

AD-55639

331011
TENSILE TESTS OF LARGE SPECIMENS REPRESENTING THE INTERSECTION OF A BOTTOM LONGITUDINAL WITH A TRANSVERSE BULKHEAD IN WELDED TANKERS
Investigations of three discrete designs of a bottom longitudinal connection at a bulkhead were made to furnish information on their relative mechanical behavior when loaded in tension. All specimens failed with cleavage

fractures after varying amounts of plastic deformation. Generally the energy to fracture increased with tesf temperature. Results of the tests to failure near 0 deg F indicate that the modifications to the basic T-2 design were beneficial, increasing the capacity of the interrupted longitudinals to absorb the energy of deformation. Comparisons of maximum load, over-all elongation, and energy to fracture for the three longitudinal designs indicate that qualitatively the order of merit for this connection is (1) through longitudinal of experimental design, (2) through-bracket longitudinal of Navy oiler design and (3) modified interrupted longitudinals for T-2 tankers. Additional tests are needed to determine whether the superior performance of the through longitudinal design can be maintained when the necessary modifications for tanker service are introduced.

Irwin, LK Campbell, WR
National Bureau of Standards, Ship Structure Committee, (Project NS-731-034) Final Rpt. SSC- 68, Jan. 1954, 68p, 8 Ref.

ORDER FROM: NTIS

AD-78999

331012
AN EVALUATION OF CURRENT KNOWLEDGE OF THE MECHANICS OF BRITTLE FRACTURE

An explanation is given of the trend of results found in the many static model tests based on the concepts and some solutions of the mathematical theory of plasticity. Transition temperature, size effect, initiation and propagation of cracks are discussed qualitatively and on dimensional grounds. The conclusion is reached that future model tests should be made at the operating temperatures of the prototype and at stress levels encountered in practice if fundamental information is to be obtained. Load, energy, or appearance criteria for static or impact tests appear to be interpretable only in terms of such basic tests or information from the prototype. Each new material or variant of an existing one should be subjected to the basic tests before an acceptance test standard can be relied upon.

Papers and discussions presented at the Conference on Brittle Fracture Mechanics held at MIT, 15-16 October 1953.

Drucker, DC
Brown University, Ship Structure Committee SSC- 69, May 1954, 239p, Refs.

Contract NObs-50148

ORDER FROM: NTIS

AD-79000

331013
A REVIEW OF SHIP STEEL RESEARCH AND RECOMMENDATIONS FOR FUTURE STUDIES

This report has been prepared at the request of the Committee on Ship Steel to review the research work completed on "Ship Steel" during the past decade, and particularly that conducted during the last five years. The report has been organized primarily to assist the Committee in evaluating the work and to aid in formulating new research proposals to be recommended for support by the Ship Structure Committee. It has therefore been drafted primarily for metallurgists who have a comprehensive background in the brittle fracture of mild steel.

Barrett, CS Mahin, WE
Chicago University, Ship Structure Committee SSC- 70, Feb. 1954, 43p

Contract NObs-50148

ORDER FROM: NTIS

AD-79001

331014
THE INFLUENCE OF HEAT TREATMENT ON THE NOTCHED-BAR PROPERTIES OF SEMIKILLED PLATE

The cooling rate after rolling varies from one steel plant to another. This variation changes the microstructure and appeared very likely to affect the notched-bar properties of the steel plates. From these facts, a comprehensive study of the effect of austenitizing temperature and cooling rate on notched-bar properties of ship plate steel seemed desirable. Results of this study can be used to estimate the effect of rolling temperature and of cooling rates from rolling temperatures on the notched-bar properties of semikilled steel plate.

Frazier, RH Boulger, FW Lorig, CH
Battelle Memorial Institute, Ship Structure Committee Prog Rpt. SSC-71, Mar. 1954, 36p, 9 Ref.

Contract NObs-53239

ORDER FROM: NTIS

AD-79002

331015
THE PRESENT STATUS OF NONDESTRUCTIVE TEST METHODS FOR INSPECTION OF WELDED JOINTS IN SHIP STRUCTURES

The nondestructive test methods applicable to flaw detection in welds in ship structures are radiography, magnetic particle, ultrasonics, and fluid penetrants. At present, radiography is the most extensively used. The magnetic-particle method has found considerable application, and fluid penetrants are used occasionally, while the ultrasonic method has not yet been used on ship structures. Radiography, at present, is the most reliable and offers the best sensitivity to the detection of flaws in welds. The ultrasonic method offers a considerable potential and may prove more expedient than radiography if developed to provide the quality of inspection desired in welds in ship structures. The magnetic-particle method is established to the point where it serves as a useful inspection tool, particularly when used in conjunction with radiography. Further development may enhance its applicability. Filmless techniques such as xeroradiography and fluoroscopy offer some potential, but both require further research and development before they may be applicable to this type of inspection. The purpose of this report is to discuss the applicability of existing nondestructive test methods to the detection of flaws in welded joints in ship structures, and to make recommendations for further research, designed to improve these methods for the above purpose.

Krieger, RJ Wenk, SA McMaster, RC
Battelle Memorial Institute, Ship Structure Committee Survey Rpt SSC-72, Oct. 1953, 29p, 3 Ref.

Contract NObs-50148

ORDER FROM: NTIS

AD-29450

331016
A REVIEW OF THE INFLUENCE OF COMPOSITION AND DEOXIDATION ON THE PROPERTIES OF SHIP PLATE STEELS

The purpose of the project was to study the influence of chemical composition and deoxidation on the transition temperature and tensile properties of 200-pound laboratory melts of semikilled ship steel rolled into 3/4-inch plates. Two base compositions were investigated--one, a 0.25% C and 0.45% Mn type, similar to ABS Class A; and the other, a 0.21%C and 0.75% Mn type, similar to ABS Class B. The principal deoxidizing elements studied were silicon and aluminum. Some of the experimental heats were made with deoxidizers added in amounts above 0.10% Si or 0.010% Al. Such heats would be classified as killed rather than semikilled. Some of these conformed to the base compositions of ABS Class C steel, which is a 0.15 to 0.30% Si type made to fine-grained practice (usually containing about 0.03% acid soluble aluminum). As the project approached completion, it was apparent that certain relationships had become reasonably well established. This, coupled with the interest expressed by the Ship Structure Committee in exploring the possibility of using steels of lower carbon content and hence lower tensile strength to obtain lower transition temperature, prompted the Committee on Ship Steel to request the Project SR-110 Advisory Committee to review the results of the investigation and prepare this interpretive report.

Ship Structure Committee SSC- 73, Nov. 1953, 35p, 7 Ref.

Contract NObs-50148

ORDER FROM: NTIS

AD-49367

331017
ELECTRON MICROSCOPE TECHNIQUES FOR STUDY OF FRACTURED SURFACES OF SHIP PLATE STEELS

This project was directed toward developing and evaluating the use of replica techniques in the electron microscope study of fractured surfaces of ship plate steels. Its ultimate aim was to further the understanding of the micro-mechanism of fracture. Using 3/4-in. Navy tear test specimens, an iron single crystal specimen formed by the carbonyl process and a specimen of actual ship plate failure taken from a C-2 cargo ship, a satisfactory electron microscope replica technique for use directly on fractured metal surfaces has been demonstrated. This technique was found to be reproducible and capable of manifesting fine and coarse structures. It produces electron micrographs which give structures that can be measured, defined and classified.

Revere, A Jaccodine, R
Stevens Institute of Technology, Ship Structure Committee Final Rpt. SSC- 74, Jan. 1959, 19p, 13 Ref.

Contract NObs-55577

ORDER FROM: NTIS

AD-211076

331018
WELDED REINFORCEMENT OF OPENINGS IN STRUCTURAL STEEL TENSION MEMBERS

The purpose of this research has been the investigation of some of the geometric factors which affect the performance of plates with reinforced openings, such as the shape of opening, the type and amount of reinforcement, and the width and thickness of the body plate. Some of the tests were repeated at low temperatures to bring in the factor of cleavage fracture. In the course of the project, a considerable amount of work was directed toward determining the nature of the plastic flow which precedes the initiation of fracture and the conditions which precipitate fracture. Specific recommendations based on the findings of the investigation have been made with respect to the design of openings and their reinforcement. Many of the results of the research are applicable to welded structures in general. The extensive test work required the use and development of somewhat new research methods and techniques. The applicability of Nadai's octahedral strain energy method, the plastic stress computation, and the resistance-wire grid system of measurements for plastic strain studies are mentioned as particularly useful.

Vasarhelyi, D Hechtman, RA
Washington University, Seattle, Ship Structure Committee Final Rpt. SSC- 75, Mar. 1955, 66p, 16 Ref.

Contract NObs-50238

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AD-78140

331279
INVESTIGATION OF PERFORMANCE OF SEMIKILLED CARBON STEEL ABS CLASS B AND RIMMED STEEL ABS CLASS A UNDER DIRECT EXPLOSION TEST

The principal result of this investigation indicated a marked improvement in performance of fully killed steel when welded with low hydrogen electrodes over the performance of the same steel when welded with cellulose type electrodes. The difference in performance of semikilled steel when welded with the two respective grades of electrodes was less pronounced, the net effect being to approximate the performance of killed steel when welded with cellulose type electrodes. Although considerable scatter was observed to exist in the performance of semikilled steel plates welded with low hydrogen electrodes, even the specimens exhibiting the poorest performance still appeared to maintain a substantial, although not spectacular, superiority over the plates welded with cellulose type electrodes. Accordingly, it was decided that an additional investigation should be conducted to determine the degree of magnitude of improvement of structural performance which the use of low hydrogen electrodes produced in semikilled steel and, if possible, to establish whether it was of real significance. In addition, a brief investigation of the performance of rimmed steels under the Direct Explosion Test was also undertaken. An additional original objective of this investigation was a comparison of performance evaluation by Direct Explosion Test with performance evaluation by the Stand-off (Explosion Bulge) Test as developed by the Naval Research Laboratory. However, because of the difference in performance existing between different plates of the heat of steel purchased, the results of this comparison appear to be somewhat inconclusive.

Mikhalapov, GS Snelling, WA
Metallurgical Research & Development Company, Inc, Ship Structure Committee Final Rpt. SSC- 76, July 1954, 45p, 6 Ref.

Contract NObs-2386

ORDER FROM: NTIS

AD-49641

331280
PART I: CRACK-STARTER TESTS OF SHIP FRACTURE AND PROJECT STEELS

The performance of rimmed and semikilled steels involved in ship fractures is investigated by means of crack-starter tests. In these tests a sharp crack is introduced in the steel, and the relative resistance to the initiation and propagation of fracture is established over the range of service temperatures. It is demonstrated that in the presence of the sharp crack the steels have no appreciable ductility when the temperature falls below the Charpy V 10ft-lb transition; accordingly, fracture initiation is readily developed. The propagation of brittle fracutres becomes difficult at temperatures above the Charpy V 15--25 ft-lb transitions. These findings are in agreement with National Bureau of Standards data for ship fracture plates. It is demonstrated that fully killed steels do not follow these rules and that the respective initiation and propagation characteristics of fracture are related to higher Charpy V values. Wide plate, tear and Charpy V test data are discussed with reference to differences related to deoxidation practice.

Puzak, PP Schuster, ME Pellini, WS
Naval Research Laboratory, Ship Structure Committee, (BuShips NS-011-067) Final Rpt. SSC- 77, June 1954, 60p

ORDER FROM: NTIS

AD-45652

331281
PART II: INVESTIGATION OF THE PERFORMANCE OF WELDMENTS AND PRIME PLATE OF ABS-B STEEL

The relative performance of G180 and E6010 ABS-B ship plate weldments and prime plate was evaluated by the Explosion Bulge Test. The prime plate loses its ability to develop extensive deformation prior to fracture in the range of-60 deg to-80 deg F; the G180 weldment develops a similar loss in the range of 20 deg to 0 deg F, and the E6010 weldment in the range of 40 deg to 0 deg F. The effects of various types of defects, including arc strikes, porosity, and partial penetration, were investigated. It is shown that in the service temperature range of 20 deg F to 60 deg F only sharp, crack-like defects, such as developed by arc strikes, are sufficiently critical to eliminate extensive plastic deformation of weldments prior to failure. The effects of shot peening of ABS-B steel is demonstrated to be detrimental with respect to the resistance of this steel to initiation and propagation of brittle fractures. Wrought iron considered as a possible material for crack arrestor straps is demonstrated to be less resistant to brittle fracture than ABS-B steels.

Pellini, WS Eschbacher, EW
Naval Research Laboratory, Ship Structure Committee, (BuShips NS-011-067) Final Rpt. SSC- 78, June 1954, 28p, 6 Ref.

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AD-45653

331282
CRACKING OF SIMPLE STRUCTURAL GEOMETRIES

This report presents the results of an investigation concerning the general subject of the cracking of simple structural geometries under tensile loading. A summary is given of the effects of edge notch geometry and the effects of interrupted longitudinal members which were previously reported in Progress Reports I and II of this project, whereas the effects of edge preparation, the effects of fastenings, and the effects of welded pads are reported in their entirety for the first time.

Carpenter, ST Linsenmeyer, RF
Swarthmore College, Ship Structure Committee Final Rpt. SSC- 79, Jan. 1955, 93p, 4 Ref.

Contract NObs-50250

ORDER FROM: NTIS

AD-79003

331283

AN INTERPRETIVE REPORT ON THE METALLURGICAL AND ECONOMIC ASPECTS OF SHIP STEELS AND THEIR RELATION TO SHIP FAILURES

One of the purposes of this report is to establish the current status of research and of shipbuilding practice relating to the reduction of brittle behavior of plating in ships. This interpretive report also considers several aspects of the fracturing problem in ships: 1. The factors that affect the brittle fracturing of ships. 2. The feasibility of eliminating the tendency toward brittle fracture in ships. 3. The relationship between the brittle fracturing of ships built during a future emergency and the notch toughness of the steel used, considering the use of World War II, current, and proposed alternative steels. 4. The economic and technical factors that affect the production of ship steel of adequate notch toughness to eliminate brittle fractures. This report is a presentation of the salient findings, conclusions, and recommendations. Appended to the report are Exhibits in which more detailed accounts of the supporting information are presented.

Harris, WJ, Jr Williams, C
Battelle Memorial Institute, Ship Structure Committee Final Rpt. SSC-80, Aug. 1956, 99p, 24 Ref.

Contract NObs-72046

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AD-109109

331284

EFFECT OF GRAIN SIZE AND CARBON CONTENT ON THE LOW TEMPERATURE TENSILE PROPERTIES OF HIGH PURITY FE-C ALLOYS

Several low carbon ferrites, approximately 99.9% pure apart from added carbon and substantially free of oxygen, nitrogen and hydrogen, were prepared and tested in tension under various conditions of heat treatment, ferrite grain size, and test temperature. True stress-strain curves were calculated and the significant tensile parameters evaluated. Ferrite grain size was shown to be the sole factor determining ductility of 0.02% carbon alloys at liquid air temperature; decreasing the grain size causes a remarkable increase in ductility. With more than 0.02% carbon, carbide morphology has an important effect on the ductility. Heat treatments which resulted in carbides at the grain boundaries materially reduced the low temperature ductility. The exponent of strain hardening was found to decrease with decreasing temperature, increasing carbon content, and increasing grain size. The initial presence of a substructure or a decrease in grain size markedly increased the yield stress at liquid air temperatures. Twinning was not found to contribute to the low temperature brittleness.

Smith, RL Spangler, G Brick, RM
Pennsylvania University, Philadelphia, Ship Structure Committee Prog Rpt. SSC- 81, May 1954, n.p., 30 Ref.

Contract NObs-50062

ORDER FROM: NTIS

AD-45267

331285

THE INFLUENCE OF CARBON AND MANGANESE ON THE PROPERTIES OF SEMIKILLED HOT-ROLLED STEEL

The performance of welded structures is closely associated with the ductile-to-brittle transition temperature of the steel from which they are made. A low transition temperature is desirable because it indicates that the steel is less likley to fail suddenly at low ambient temperatures. Structures such as bridges, ships, storage tanks, and pipelines are usually made from hot rolled semikilled steel. Changes in rolling practice or chemical composition appear to be the most practical methods for improving the toughness of such materials. This results from the fact that production is likely to be seriously curtailed if improvements were obtained by recourse to heat treatment or complete deoxidation. This paper discusses the effect of variations in carbon and manganese contents on the properties of semikilled steels. The transition temperature, a property to which considerable importance is attached, varies with specimen configuration, testing method, and criterion of performance. Both the Navy tear test and the keyhole Charpy test were used in the investigation. According to the terms used by Vanderbeck and Gensamer, the tear test was used to measure a fracture transition and the Charpy test to measure a ductility transition. In either case the specimens absorb considerably less breaking energy in tests below the transition temperature than in tests above the transition temperature. Decreasing the testing temperature of notched-bar specimens seems to be equivalent in its effect to increasing the severity of loading on fabricated structures. Therefore, structures built from steels exhibiting lower transition temperatures in laboratory tests are expected to be less susceptible to sudden brittle fractures in service. Consequently, changes in composition which lowered the transition temperature of the experimental steels were judged desirable.

Boulger, FW Frazier, RH Lorig, CH
Battelle Memorial Institute, Ship Structure Committee Prog Rpt. SSC-82, Oct. 1954, n.p.

Contract NObs-53239

ORDER FROM: NTIS

AD-79004

331286

REPRODUCIBILITY OF KEYHOLE CHARPY AND TEAR TEST DATA ON LABORATORY HEATS OF SEMIKILLED STEEL

Eighteen heats of semikilled steel were made, processed to 3/4-in. plates, and tested in the laboratory. Analytical and mechanical test data showed that good reproducibility was obtained on replicate heats. Two types of semikilled steel were used for the investigation. Standard keyhole Charpy specimens and Navy tear-test specimens were tested to determine the transition temperature separating ductile and brittle fracture. The probability of brittle fracture was not the same for the two types of steel in tests at their transition temperatures, as customarily defined. The difference was small in Charpy tests but significant in tear tests. It is concluded that notched-bar transition temperatures should be defined on the basis of a fixed probability of brittle fracture. This practice uses the data more efficiently and is more discriminating.

Frazier, RH Spretnak, JW Boulger, FW
Battelle Memorial Institute, Ship Structure Committee Prog Rpt. SSC-83, Feb. 1955, 22p

Contract NObs-53239

ORDER FROM: NTIS

AD-79005

331287

AN APPRAISAL OF THE PROPERTIES AND METHODS OF PRODUCTION OF LAMINATED OR COMPOSITE SHIP STEEL PLATE. SPECIAL REPORT

The conclusions and opinions of the Committee on Ship Steel with regard to the use of laminated or composite steels in ships can be summarized as follows: (1) The available data indicate that plates containing layers of weakness in the thickness direction are no more effective in inhibiting crack initiation than similar homogenous materials; (2) Mild steels clad with notch tough surface layers on one or both sides have lower transition temperatures than the unclad base material, but clad materials are expensive to produce and frequently require the use of strategically critical materials. Moreover, there are homogenous steels of sufficient notch toughness available that can be produced on a tonnage basis at a much lower cost than clad steels and (3) Considerable promise in inhibiting crack initiation or propagation has been shown in preliminary tests of properly applied notch tough weld beads and strakes of notch tough plating. Further exploration of these possibilities is currently underway.

SSC- 84, Jan. 1956, v.p., 17 Ref.

Contract NObs-50148

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AD-84797

331288

EVALUATION OF WELD-JOINT FLAWS AS INITIATING POINTS OF BRITTLE FRACTURE

A literature survey was made to determine the fundamental factors and circumstances that are known about brittle fractures in ship steels and similar materials. The survey was the initial part of this investigation for the Ship Structure Committee under Bureau of Ships contract 61748 on the evaluation of flaws in weld joints. Various testing methods and specimens used in previous investigations involving brittle fracture were reviewed. Preliminary studies were made to determine the best method of introducing flaws into weld joints to simulate the flaws found in service failures. A major portion of the effort on the project has been involved with determining: (a) what kind of test specimen and apparatus should be used to evaluate weld-joint flaws; (b) what kind of loading or types of loading are needed to simulate service conditions in ships or other large structures; and (c) what nominal stress is required to initiate a brittle fracture from large weld cracks and other flaws such as lack of weld fusion. A significant result has been that brittle fractures initiate from the weld defects in the laboratory specimen under conditions very close to the reported conditions involved in some service failures of ships.

Martin, DC Ryan, RS Rieppel, PJ
Battelle Memorial Institute, Ship Structure Committee Prog Rpt. SSC-86, Sept. 1956, 88p

Contract NObs-61748

ORDER FROM: NTIS

AD-106299

331289

RAPID PROPAGATION OF A CRACK IN A BRITTLE MATERIAL

In this report an attempt is described to apply the mechanics of the continuum to the problem of the propagation of a crack in a plate being in a one-dimensional state of stress by static external loads. It is necessary to assume that the crack has already reached the point where the rapid increase of velocity of propagation begins.

Schilhansl, MJ
Brown University, Ship Structure Committee Prog Rpt. SSC- 87, Mar. 1955, 25p, 10 Ref.

Contract NObs-65917

ORDER FROM: NTIS

AD-79006

331290

INFLUENCE OF SILICON AND ALUMINUM ON THE PROPERTIES OF HOT-ROLLED STEEL

Killed steels are known to have lower transition temperatures than semikilled steels. It is believed that the better qualities of killed steels in this respect are due mainly to the low oxygen contents of the steel. The principal deoxidizers, aluminum, silicon, and manganese, lower the oxygen content. Fundamental studies have shown that the oxygen content remaining after the addition of one of these three elements is influenced by the residual amounts of the other two present. In the current study, therefore, various amounts of silicon and aluminum were added to steels containing different manganese contents for the purpose of studying the influence of silicon and aluminum on the notched-bar properties of hot-rolled steels. Eleven types of steels were studied of the nominal compositions. Both the Navy tear test and the keyhole Charpy test were used in this investigation. The temperature at which the plates were finish rolled was carefully controlled at 1850 F, and all plates were rolled to 3/4-in. thickness, followed by testing in the as-rolled condition.

Frazier, RH Boulger, FW Lorig, CH
Battelle Memorial Institute, Ship Structure Committee Prog Rpt. SSC-88, July 1955, 86p, 13 Ref.

Contract NObs-53239

ORDER FROM NTIS

AD-79007

331291

EFFECT OF ACCELERATED COOLING AFTER HOT ROLLING ON THE NOTCHED-BAR PROPERTIES OF SHIP PLATE STEEL

The results of this work may be summarized as follows: (1) Water quenching 3/4-in. plates for six seconds did not raise the hardness in the center of the plate. Longer quenching times increased the center hardness, an indication that the ultimate strength of the plate was increased. The hardness at the edge of all plates quenched was approximately 95 R sub B, with the higher carbon steel having the highest surface hardness. (2) The microstructure of the center of plates, quenched for periods longer than six seconds, was no longer typical of as-rolled steel but, instead, tended to show ferrite outlining the original austenite grain areas. The centers of the quenched plates also showed some Widmanstatten structures. The transition temperature, when the 12 ft-lb keyhole notch Charpy criterion was used, was lowered by quenching the plates from the last hot-rolling pass. Longer quenching times gave lower transition temperatures. The higher manganese Steel W-5 appeared to be more adaptable to quenching than Steel W-1, since the shape of the keyhole Charpy transition curves for Steel W-5 was not altered by quenching. (4) In general, increasing the length of the quenching time lowered the tear test transition temperature. An exception was the plate of Steel W-1 which was quenched in water for 25 seconds before being air-cooled. This plate had a higher transition temperature than the plates which had been quenched for shorter times or air-cooled from the last hot-rolling pass.

Frazier, RH Boulger, FW Lorig, CH
Battelle Memorial Institute, Ship Structure Committee Prog Rpt. SSC-89, July 1955, 25p

Contract NObs-53239

ORDER FROM: NTIS

AD-78008

331292

EFFECTS OF ALUMINUM ADDITIONS AND VARIATIONS IN FINISHING TEMPERATURE ON PROPERTIES OF HOT-ROLLED EXPERIMENTAL OPEN-HEARTH STEELS

The results obtained in this investigation on experimental open-hearth steels of ship plate composition justify the following conclusions: 1. The Charpy and tear test transition temperatures of hot-rolled plates were not changed significantly by aluminum contents in the range up to 0.04 per cent. 2. Variations in the temperature of the final hot-rolling pass in the range from 1650 F to 2050 F influenced the transition temperature of the laboratory rolled steel. Each increase of 100 F in finishing temperature raised the transition temperature 6 F in Charpy keyhole tests and 8 F in tear tests. 3. The ferrite grain size of hot-rolled steels of ship plate composition was independent of variations in aluminum content up to 0.04 per cent. Higher finishing temperatures produced coarser ferrite grain sizes. 4. Steels containing more than 0.01 percent acid-soluble aluminum had higher austenite grain-coarsening temperatures than semikilled steels. Therefore, normalizing aluminum killed steels from 1650 F produced finer ferrite grains than normalizing semikilled steels from the same temperature. 5. Normalizing from 1650 F lowered the Charpy transition temperatures of the ship plate steels investigated. The beneficial effects of normalizing were more pronounced for aluminum killed steels than for semikilled steels.

Frazier, RH Boulger, FW Lorig, CH
Battelle Memorial Institute, Ship Structure Committee Prog Rpt. SSC-90, July 1955, 33p, 7 Ref.

Contract NObs-53239

ORDER FROM NTIS

AD-75454

331293

INVESTIGATION OF THE INFLUENCE OF DEOXIDATION AND CHEMICAL COMPOSITION ON NOTCHED-BAR PROPERTIES OF SHIP PLATE STEELS

This report summarizes the results of the investigation which included studies on approximately 400 steels. In order to condense the information, references are made to progress reports containing original data supporting conclusions drawn in this report. Some technical articles based on these reports have been published. The majority of the data was obtained on steels made in 200-lb. melts and processed in the laboratory. All of the laboratory

heats were made in an induction furnace using standardized melting practices. Unless otherwise noted, they were rolled to 3/4-in. plate using a finishing temperature of 1850 F. Two base compositions for semikilled steels were investigated. One was similar to ABS Grade B steel in composition (Type B heats). The other was similar to ABS Grade A steel (Type A heats) and resembled the ship steel used during World War II. The effects of carbon, maganese, phosphorus, nitrogen, and sulfur were investigated on semikilled steels. Silicon and aluminum were the principal deoxidizers studied. The investigation of composition was supplemented by limited studies of the effects of hot working and cooling variables on notched-bar properties and fracture characteristics of ship plate steel.

Boulger, FW Frazier, RH Lorig, CH
Battelle Memorial Institute, Ship Structure Committee Final Rpt. SSC-91, July 1955, 58p, 31 Ref.

Contract NObs-53239

ORDER FROM: NTIS

AD-75455

331294
LOW TEMPERATURE EMBRITTLEMENT MECHANICS DEDUCED FROM ZINC SINGLE CRYSTAL FRACTURE STUDIES

This study of the kinematics of fracture of zinc single crystals, made by deforming and examining the crystals in stages, revealed that primary cleavage generally began on the inert side of the kink plane near the shoulder and tended to continue into the shoulder. Increasing the size of the shoulder relative to the area of the actively slipping test section repressed the tendency of crack to continue into the shoulder. This variation favored further deformation of the test section and thus increased the ductility of the specimens. This study also confirmed previous work, which showed that orientation gradients, originally wrought by constraints, and not twinning, cause brittle fracture. This is true whether sectional area changes or twinned-untwinned areas change.

Treon, R, Jr Baldwin, WM, Jr
Case Western Reserve University, Ship Structure Committee Final Rpt. SSC- 92, Nov. 1958, 33p, 17 Ref.

Contract NObs-72046

ORDER FROM: NTIS

AD-206684

331295
MECHANICAL PROPERTIES OF HIGH PURITY FE-C ALLOYS AT LOW TEMPERATURES

Results of the second phase of an investigation on several high-purity, low-carbon irons in the alpha region of the Fe-C diagram which was made in an attempt to correlate brittle behavior, as defined by the Charpy V-notch transition temperature, with yield-point and fracture data from uniaxial tension tests are summarized in this report. All of the alloys tested showed a sharp rise in impact transition temperature corresponding to the precipitation of Fe Sub 3 C. The data also indicate that ferrites with veining have higher transition temperatures than those without veining as quenched from the alpha or unsaturated region. Two of the alloys show a decrease in the transition temperature of the ferritic structures as saturation is approached. Two hypotheses are advanced to explain this: 1) as the temperature is lowered in the alpha region, the concentration of carbon atoms at grain boundaries increases, and 2) carbon segregates at sub-grain as well as at primary boundaries and in some way "strengthens" the sub-grain boundaries so that they assume more of the properties of high-angle grain boundaries.

London, GJ Spangler, G Brick, RM
Pennsylvania University, Philadelphia, Ship Structure Committee Prog Rpt. SSC- 93, Mar. 1959, 25p, 5 Ref.

Contract NObs-50062

ORDER FROM NTIS

AD-219818

331296
MECHANICAL PROPERTIES OF HIGH PURITY FE-C ALLOYS AT LOW TEMPERATURES

The mechanical properties of high-purity iron-carbon alloys, 0.003 to 0.49% carbon, at low temperatures were investigated. Results obtained indicate that the binary ferrites do not differ qualitatively from commercial ferritic steels in low-temperature behavior, assuming that in both cases oxygen contents are sufficiently low for fractures to be transcrystalline rather than intercrystalline. The study indicates that the exponent of strain hardening appears to be more significant in defining low-temperature brittleness than the slope of the uncorrected stress-strain curve. An hypothesis is also extended that while carbides initiate cracks, they also interfere with crack propagation and thus reduce the abrupt change from ductile to brittle behavior upon a decrease of temperature.

Brick, RM
Pennsylvania University, Philadelphia, Ship Structure Committee Final Rpt. SSC- 94, Mar. 1959, 14p, 4 Ref.

Contract NObs-50062

ORDER FROM: NTIS

AD-219817

331297
THERMAL STRESSES IN SHIPS

This reprot reviews the information in the literature on thermal strains and stresses in ships as well as theoretical methods of analysis which may be applied thereto. Localized heating by the sun has been observed in a number of ships. Almost no observations of temperature effects have been made on ships under the weather conditions and sea temperatures which prevailed at the time of serious ship failures. Evidence was found in connection with brittle fractures of Group I severity that thermal stresses may have been a significant factor in the failure of at least thirty tankers and an equal number of dry cargo ships. In some of these cases thermal stresses were the prime factor. In the remainder, heavy weather or other elements were also contributory. Theoretical methods were found which would predict with fair accuracy the nominal thermal stresses and deflections in the hull girder of a ship if the distribution of temperature were found which would yield actual rather than nominal stresses. The small amount of information on the subject of thermal stresses applicable to ships indicates the desirability of more research in this field.

Hechtman, RA
George Washington University, Ship Structure Committee Final Rpt. SSC- 95, Oct. 1956, 155p, 70 Ref.

Contract NObs-72046

ORDER FROM NTIS

AD-114021

331298
NOTES ON THE INFLUENCE OF UNFAIR PLATING ON SHIP FAILURES BY BRITTLE FRACTURE

It was found that the unfairness of bottom or deck plating does not raise the tensile stresses to any significant degree. As any influence of unfairness on the danger of brittle fracture could be only through an increase of the tensile stresses, it is finally concluded that plating unfairness per se has no significant bearing on the problem of brittle fracture.

Bleich, HH
Columbia University, New York, Ship Structure Committee Final Rpt SSC- 96, Mar. 1956, 47p, 8 Ref

Contract NObs-50148

ORDER FROM NTIS

AD-109676

331299
THE MECHANISM OF BRITTLE FRACTURE

This report reviews the general form of stress-temperature relationship for the crack arrest test and the effect of grain size on grain controlled mild steel, ordinary mild steel and the effect on upper arrest and critical stress. Stress ahead of a crack front for various nominal transverse stress conditions is discussed as well as the possible relations among yield strength, size of grain, temperature and arrest temperature.

Robertson, TS
Naval Construction Research Establishment, Ship Structure Committee SSC- 97, Mar. 1955, 15p

ORDER FROM: NTIS

AD-78139

331300
ENERGY RELEASE RATES DURING FRACTURING OF PERFORATED PLATES

A preliminary study of energy release rates in simple structures has been made. These simple structures consisted of 75ST specimens 6-in. wide, 12-in. long, and .032-in. thick. The specimens contained holes of various geometric shapes: circles, ellipses, squares, and slots. Symmetrical slots which serve as crack simulators of increasing length were introduced at the extremities of the holes. Energy release rates of the specimens with slots up to 2/3 the plate width were measured and compared with rates for a plate containing a simple slot alone. The energy release rates for the plates containing a hole-slot combination were quite similar to the rates for plates containing simple slots. Thus the instability stress for a plate containing a hole from which a crack has started should be approximately equal to the instability stress for a plate containing a crack of length equal to the hole-crack combination. Comparisons of test results with theoretical values show good agreement with a function of the Griffith type for the full range of slot lengths evaluated. Agreement of test results with the modified Greenspan relation was satisfactory up to ratios of slot width to plate width of 1/4. Beyond this range the experimental rate was considerabley less than the calculated rate.

Brossman, MW Kies, JA
Naval Research Laboratory, Ship Structure Committee, (NRL Memo Rpt 370) SSC- 98, Apr. 1955, 21p, 9 Ref.

ORDER FROM: NTIS

AD-79009

331301
NOTCH-TOUGHNESS PROPERTIES OF ABS SHIP PLATE STEELS

This project is concerned with a survey of the notch-toughness properties and other characteristics of mild steel ship plate as procured by various commercial shipyards for new merchant ship construction under the American Bureau of Shipping Rules. The over-all objective is to determine the extent to which present-day ship plate steels have been improved, based principally upon a comparison of their Charpy V-notch properties with those established at the National Bureau of Standards on plates from fractured World War II ships. Samples of Classes A, B, and C plates are being furnished on a continuous basis by the U. S. Coast Guard and represent scrap material remaining from plates used in new ship construction. Information relative to the background history of the samples is meager. To date, 32 Class A, 80 Class B, and 16 Class C plate samples (total 128) have been received. On each sample, the Material Laboratory determined the chemical composition (C, Mn, Si, Al), ferrite and McQuaid-Ehn grain sizes, static tensile properties, notch-toughness properties as evaluated by Navy tear tests at selected temperatures, and Charpy V-notch and keyhole-notch transition temperatures. This progress report presents data obtained on 8 Class A, 44 Class B, and 8 Class C samples (total 60). On the basis of comparison of the 15 ft-lb Charpy V-notch transition temperatures with those established by the National Bureau of Standards, the preliminary findings indicate that the notch-toughness properties of ABS ship plate of current manufacturer are considerably better than those of plate made during World War II.

Kahn, NA Imbembo, EA Gabriel, JJ
Naval Material Laboratory, Ship Structure Committee SSC- 99, June 1955, 30p, 6 Ref.

ORDER FROM: NTIS

AD-78007

331711
INDEX OF SHIP STRUCTURE COMMITTEE PUBLICATIONS

This report is an index to all publications of the Ship Structure Committee between the time of its formation in 1946 and February 28, 1958. The index is divided into three sections. Section I consists of three portions that contain all of the reports distributed by the Ship Structure Committee. Part A is a listing of all Ship Structure Committee reports by serial number from 1 through 110, including other pertinent information such as authors, type of report (progress, final, special, survey, or interpretive), and date of publication. Part B includes Ship Structure Committee reports that do not bear serial numbers. Part C contains a listing of miscellaneous reports and papers that were not published by the Ship Structure Committee but are closely related to the Ship Structure Committee program. Section II lists research projects together with all Ship Structure Committee reports published in connection with each project as set forth in Section I. Section III cites references to reports listed in Section I that have been reproduced in whole or in part in other technical literature. In addition, references are given to articles that have been published as a result of Ship Structure Committee sponsored work.

Fisher, MB
Ship Structure Committee, (0022-1821) SSC-100, Apr. 1958, 34p

Contract NObs-72046

ORDER FROM: NTIS

AD-161084

331712
IMPROVED NOTCH TOUGHNESS OF EXPERIMENTAL SEMIKILLED STEELS OVER ONE INCH IN THICKNESS

A substitute for ABS Class C killed ship plate steel (over one inch thick) is desirable because it is likely that during an emergency hot-topping capacity would not be available for the production of ship plate. To provide a semikilled steel of suitable toughness, a cooperative investigation was undertaken to produce and test two 25-ton basic open-hearth semikilled heats containing lower carbon and higher manganese than present ship plate steels. Tests on the plate product indicate that this steel is tougher than presently used semikilled grades and should be sufficiently tough to consider as an emergency substitute, or possibly as an alternate, for ABS Class C steel in thicknesses over 1 in. to 1-3/4 in. inclusive. To meet the tensile properties specified by the American Bureau of Shipping for hull steel, it is tentatively recommended that the composition range for the proposed steel be 0.20% carbon maximum and 1.00 to 1.35% manganese. The proposed steel should have about the same sensitivity to underbead cracking as ABS Class C steel. It is recommended that a number of full-size heats be made and tested so that average properties and the likely range of properties may be better determined and optimum deoxidation practices established.

Vanderbeck, RW
United States Steel Corporation, Ship Structure Committee Prog Rpt. SSC-101, 1956, 53p, 12 Ref.

Contract NObs-72046

ORDER FROM: NTIS

AD-106452

331713
THE RELATION OF MICROSTRUCTURE TO THE CHARPY IMPACT AND LOW-TEMPERATURE TENSILE PROPERTIES OF TWO SHIP STEELS

This report describes the influence of the microstructural features on the brittle behavior of two ship plates, one a semikilled steel (ABS Class B) and the other a rimming steel (project steel E). The ferrite-pearlite aggregates were varied systematically by means of annealing and normalizing treatments, and correlations were obtained between the brittle behavior and several accurately measured microstructural parameters. Part I is concerned with observations on polished specimens after deformation in tension and slow-bend tests at-195 deg C, as well as at room temperature, to assess the role of twinning and to study the morphology of slip and brittle fracture. Part II describes the quantitative influence of microstructural variables on the Charpy V-notch transition temperature. Part III reports on measurements of deformation prior to brittle fracture in tension specimens at-195 deg C and considers the effect of the microstructure on the tensile properties in the brittle range.

Owen, WS Whitmore, DH Sullivan, CP Averbach, BL Cohen, M
Massachusetts Institute of Technology, Ship Structure Committee Prog Rpt. SSC-102, June 1956, 79p, 73 Ref.

Contract NObs-65918

ORDER FROM: NTIS

AD-106390

331714

THE TENSILE YIELD BEHAVIOR OF SHIP STEEL

The preyield strain phenomena at room temperature and -195 deg C are examined in two ship steels, (an ABS class B semikilled steel and a rimming steel designated "project steel E"), as a function of annealing and normalizing temperature and the ferrite grain size. The yield points are measured by an approximately constant strain rate test, the load increasing continuously to the upper yield point. A step-load technique with SR-4 electrical resistance gages is used to determine the elastic limit and the preyield strain. These experiments are supplemented by microscopic observations on prepolished tensile specimens. While the stress levels for the initiation of microstrain, creep, and gross yielding are all predominantly chemistry and grain size dependent, the strain rate in each range is primarily a function of the annealing or normalizing temperature employed.

Owen, WS Averbach, BL Cohen, M
Massachusetts Institute of Technology, Ship Structure Committee Prog Rpt. SSC-103, Sept. 1956, 37p, 23 Ref.

Contract NObs-65918

ORDER FROM: NTIS

AD-108862

331715

WELD FLAW EVALUATION

This is a detailed final report on a series of investigations made to determine a basis for the evaluation of the ability of weld flaws to initiate brittle fracture. The report is in four parts dealing successively with (1) brittle fracture mechanics based on the Griffith theory and on Irwin's strain-energy release rate adaptations, (2) static tests on flawed butt welds, (3) static and dynamic tests on small butt weld flaws with and without residual stress, and (4) static tests on weld flaws in a controlled field of high residual stress. All welding flaws in selected materials were simulated flaws, varied to represent lack of penetration, porosity, lack of fusion, or sharp internal weld cracks. The major objective was to examine the effect of given flaws in various environments, in order to determine the environment essential to initiate brittle fracture under low static stress conditions. Low temperature was generally an essential part of the environment, but low static stress initiation could not be procured below the nominal yield point unless the static stress was augmented by either a dynamic stress or a high previously-incurred residual stress. The residual stress environment proved to be most significant. Brittle fractures were initiated from short internal cracks with as small as 2000 psi of applied static stress at temperatures in the order of 0 deg F. If total brittle fracture did not result, arrested fractures occurred from small buried flaws, with the arrested crack forming a potential source of fracture initiation. Finally, this report emphasizes the important bearing that residual stress has on the brittle fracture problem and the need for extended investigations in brittle fracture mechanics based on strain-energy release rates to furnish a complete engineering basis for flaw evaluation.

Carpenter, ST Linsenmeyer, RF
Swarthmore College, Ship Structure Committee Final Rpt. SSC-105, July 1958, 117p, 14 Ref.

Contract NObs-72060

ORDER FROM: NTIS

AD-201631

331716

MILL SAMPLING TECHNIQUES FOR QUALITY DETERMINATION OF SHIP PLATE STEEL

In order to obtain information on the variation of mechanical properties within typical heats of currently produced ship plate steel, 54 plates from 6 heats were obtained from two producers, United States Steel Corporation and Bethlehem Steel Company. The former contributed 27 plates of 3/4-in. ABS-Class B, and the latter contributed 27 plates of 1-1/4-in. ABS-Class C. All were made to the ABS Specification in effect prior to February 1, 1956. A sample of 24 of these plates was selected to provide data on the variations among plates, ingots, and heats. Five additional plates were subsequently tested to resolve doubtful cases. Although primary interest was on the notch toughness characteristics, the static tensile properties, ferrite grain size, and chemical composition were also measured. In addition, the severity and extent of segregation in some of the plates was studied, and the influence of segregation on impact test results was examined. Analysis of the results on the 29 plates indicates that the mechanical properties of plates in an entire heat can be satisfactorily evaluated by tests on two properly chosen sample plates.

Staugaitis, CL
National Bureau of Standards, Ship Structure Committee Prog Rpt. SSC-106, Jan. 1958, 44p, 6 Ref.

Contract NObs-72046

ORDER FROM: NTIS

AD-160562

331717

EVALUATION OF WELD-JOINT FLAWS AS INITIATING POINTS OF BRITTLE FRACTURE

This report describes a study made of the conditions needed for initiation of a brittle fracture from flaws 4 in. or less in length. Experiments performed demonstrated that residual and reaction stresses (local stresses) join with applied stresses to make up the total stress that is involved in the initiation of many brittle fractures. If local stresses are high in the vicinity of a flaw, then the applied stress may be low when brittle fracture initiates from that flaw provided that the steel is at or near the nil ductility temperature (NDT). Stress conditions that are expected to exist in ship structures were incorporated in the test specimen. Various techniques were employed to determine the magnitude of the stresses in the area of the flaw front. Some brittle fractures were initiated from flaws 4 in. or less in length at an applied stress of less than 6000 psi. Thus the results provided some insight concerning the state of stress that probably existed in structures that have failed in service at low applied stress. Service failures and the results obtained on this project show that flaws, (especially cracks), of almost any size are potential initiation points of brittle fracture. On the other hand, these results have shown that a total stress of yield-point value or higher, in conjunction with some stress-raising condition, is necessary to initiate brittle fracture under service conditions from flaws of various sizes and types (such as a crack or lack of fusion in a weld joint). In other words, it takes a combination of conditions to initiate a brittle fracture.

Sopher, RP Lowe, AL, Jr Rieppel, PJ
Battelle Memorial Institute, Ship Structure Committee Final Rpt. SSC-107, Aug. 1958, 51p

Contract NObs-61748

ORDER FROM: NTIS

AD-203935

331718

NOTCH-TOUGHNESS PROPERTIES OF SHIP-PLATE STEEL AS EVALUATED BY THE VAN DER VEEN NOTCHED SLOW-BEND TEST

On the basis of the limited amount of work reported here, the van der Veen notched slow-bend test appears to provide an estimate of the fracture transition temperature similar to that obtained in the Navy tear test. A ductility transition temperature can also be evaluated by the van der Veen test, but during the present study it appeared that more tests should have been conducted at lower temperatures in order to permit more suitable selections of the ductility transition temperature. Increased use of the van der Veen test should establish its correlation with the other tests that have been used to evaluate the notch-sensitivity characteristics of ship-plate steels. In this connection, the Material Laboratory is currently applying the van der Veen test to samples of ABS ship plate under investigation at the National Bureau of Standards as part of Ship Structure Committee Project SR-139, "Joint SSC-AISI Study."

Imbembo, EA Ginsberg
New York Naval Shipyard, Ship Structure Committee Prog Rpt. SSC-108, Aug. 1959, 21p, 4 Ref.

Contract NObs-72046

ORDER FROM: NTIS

AD-227740

331719

PRELIMINARY STUDIES OF BRITTLE FRACTURE PROPAGATION IN STRUCTURAL STEEL

This report describes the early development work on the program and the subsequent preliminary series of tests of 2-ft wide plate specimens. Initially, two methods of fracture initiation were investigated, the powder detonator bolt, which involved the use of an explosive, and the notch-wedge-impact method. Although attractive for several reasons, the detonator bolt method failed to initiate any fractures and thus was dropped from further consideration. As a result, the notch-wedge-impact method of fracture initiation has been used for all plate tests in this program to date. Other development work included specimen cooling, instrumentation, and details of specimen geometry. When the development work had progressed to a satisfactory stage, a series of tests of 2-ft wide specimens was made. These tests involved the surface measurement of crack speed and strain pattern while the fracture was propagating. Their results may be summarized as follows: 1. Crack speeds ranging from 1150 to 5900 fps were recorded. 2. Absolute peak elastic strains as high as 2500 micro in./in. (0.0025 in./in.) have been recorded in the vicinity of the fracture. 3. For vertically oriented dynamic strain gages, as the distance from the fracture to the gage increases, the magnitude of the peak strain decreases, and the pulse time increases. 4. No correlation of crack speed with texture was noted. 5. A sizable delay in the time necessary to start full propagation was noted for cracks initiated in the vicinity of a sheared edge. A comparison of the records from each group of tests indicates that, within reason, consistent data were obtained at similar gage locations under comparable test conditions.

Hall, WJ Godden, WG Fettahlioglu, OA
Illinois University, Urbana, Ship Structure Committee Prog Rpt. SSC-111, May 1958, 86p

Contract NObs-65790

ORDER FROM: NTIS

AD-202145

331901

STUDIES OF BRITTLE FRACTURE PROPAGATION IN SIX-FOOT WIDE STRUCTURAL STEEL PLATES

Presented in this Second Progress Report are the results of tests on 6-ft wide plates, conducted between November 29, 1955 and November 15, 1956, that were instrumented to measure crack speed and strain response as the brittle fracture propagated across the plate. The test procedure consisted of initiating a brittle fracture at the edge of a plate by the notch-wedge-impact method and recording strain and speed detector signals with cathode-ray oscilloscope equipment as the brittle fracture propagates across the plate. For most of the tests, the average net stress was about 18.0 ksi, and the temperature of the rimmed-steel plate was about 0 deg F. Recorded surface crack speeds ranged from 1800 to 7550 ft per sec; however, 75% of the speeds fell within the range of 2100 to 3900 ft per sec. The majority of the strain measurements recorded during crack propagation were made in the immediate vicinity of the fracture path. Strain magnitudes exceeding 0.002500 i in./in. have been measured on the plate surface near the fracture, with negligible permanent set remaining after fracture. Thus far, vertically oriented strain gages in front of the crack indicate that there is negligible strain redistribution on the section of the plate ahead of the crack. Studies indicated that the strain response associated with the initiation impact-wedging action was relatively small as compared to that recorded during the fracture process. The complete brittle fracture of a pull plate subjected to static loading with no artificial stress concentration is also reported.

Lazar, R Hall, WJ
Illinois University, Urbana, Ship Structure Committee Prog Rpt. SSC-112, Sept. 1959, 51p, 10 Ref.

Contract NObs-65790

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AD-227380

331902

FRACTURE APPEARANCE OF IMPACT SPECIMENS TAKEN FROM FRACTURED SHIP PLATES

Several thousand broken V-notch Charpy specimens from service failures were studied to determine the relation between fracture appearance and impact energy of steel from fractured ships. It was found that the 50% fibrous fracture criterion was as effective as the Charpy V-notch 15 ft-lb criterion as a means of discriminating between plate that contained the source or the terminus of the fracture, or if the plate permitted a fracture to run through it.

Bennett, JA
National Bureau of Standards, Ship Structure Committee Final Rpt. SSC-113, June 1959, 9 p, 3 Ref.

Contract NObs-72046

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AD-219930

331903

THE INFLUENCE OF FERRITE BANDING ON THE IMPACT PROPERTIES OF MILD STEEL

The object of this investigation was to compare the Charpy properties of a severely banded ferrite-pearlite structure with those of a random ferrite-pearlite distribution. Both types of specimens could be prepared from the same material by applying suitable homogenizing treatments to an initially banded steel. Some observations on the nature of the banding are described. The Charpy properties at the lower end of the testing-temperature range are not appreciably affected by the degree of ferrite banding, by the direction of the specimen axis, or by the orientation of the notch. However, in the higher temperature range, the random structure exhibits a higher energy absorption than does the banded structure and, in both cases, the Charpy values depend strongly on the orientation of both the specimen and the notch. Evidence was obtained to suggest that the fracture appearance is not sensitive to specimen orientation even in a severely banded steel, although notch orientation is a factor. No preferred crystallographic orientation of the ferrite was found in any of the specimens.

Owen, WS Cohen, M Averbach, BL
Massachusetts Institute of Technology, Ship Structure Committee Prog Rpt. SSC-114, Oct. 1958, 23p, 9 Ref.

Contract NObs-65918

ORDER FROM: NTIS

AD-212996

331904

BRITTLE FRACTURE INITIATION TESTS

A running crack will propagate at nominal stresses of 10,000 psi in steel plate. Nevertheless, structures of such steel operate at higher nominal stress. Furthermore, laboratory tests generally fail to initiate brittle fracture at nominal stresses below yield except by extreme cooling or impact loading. A strong barrier to the static initiation of brittle fracture thus exists. The object of the present investigation is to study the conditions under which this barrier is lowered. Until static laboratory tests reproduced fractures at the temperatures and nominal stresses encountered in service, brittle fracture will remain essentially unexplained. Moderate success has been achieved so far. Welded and unwelded notched steel plates with various prestrains were pulled at various temperatures. Transversely prestrained plates with punched notches fractured consistently below yield under static loading. The fractures were as brittle as those found in service in the region of propagation and, far more important, also at the point of initiation.

Mylonas, C Drucker, DC Isberg, L
Brown University, Ship Structure Committee Prog Rpt. SSC-115, Oct. 1958, 9p, 46 Ref.

Contract NObs-65790

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AD-205563

331905

STATIC BRITTLE-FRACTURE INITIATION AT NET STRESS 40% OF YIELD

Static fractures which are brittle from the start are evidence of lack of ductility at the point of crack initiation and occur at low average net stress. Past static tests, in failing generally to reproduce the phenomenon of brittle-fracture initiation, showed that undamaged steel plate under adverse notch conditions has sufficient ductility to allow general yielding before fracturing. Static initiation of brittle fracture can be achieved by an

additional exhaustion of ductility. For this purpose, a steel of high transition temperature was subjected to various types of prestraining. The best results were achieved by precompressing 3/4-in. thick 10-in. square plates with machined notches so as to produce large plastic strains at the notch roots. When tested in central static tension at a temperature below the transition range, these plates fractured at average net stresses well below yield level. The lowest average stress at fracture was 36% of virgin yield. Thus, for the first time brittle fracture of unwelded steel plate has been initiated in the laboratory under controlled conditions at such low stress. The conditions at fracture indicate that energy theories are useless or inapplicable in the problem of fracture initiation. Finally, residual stresses are shown to be of little importance when ductility is ample. When embrittlement is excessive, they only hasten a fracture which would have occurred at low applied stress in the absence of residual stress.

Mylonas, C Drucker, DC Brunton, JD
Brown University, Ship Structure Committee Prog Rpt. SSC-116, Dec. 1958, 7p, 18 Ref.

Contract NObs-65790

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AD-215142

331906
BRITTLE-FRACTURE TESTS OF STEEL PLATES CONTAINING RESIDUAL COMPRESSIVE STRAIN
This investigation was undertaken in an attempt to determine some of the effects a residual compressive-strain field may have on a propagating brittle fracture. Brittle-fracture tests were conducted on 3/4-in. thick by 2-ft wide by 5-ft long steel plates in which there was a longitudinal residual compressive strain in the central portion of each plate, and a region of high longitudinal tensile strain at each edge. This strain field was developed by welding tapered slots cut perpendicular to the edges of the plates. The tests show clearly that the residual strain field affects the initiation and propagation of a brittle fracture. In all these tests the residual tensile strain at the edge of the plate was effective in reducing the applied stress at the notch required for fracture initiation. In one test in which the fracture propagated completely across the plate, the residual compressive strain field decreased the crack speed and the associated strain response. In two other tests, in which the residual compressive strains were much greater, the brittle fractures arrested in the compressive strain fields. The results suggest the possiblity of prestressing elements of ships or structures, or perhaps entire structures, as a means of arresting brittle fractures or providing a barrier for fracture initiation.

Rolfe, ST Hall, WJ Newmark, NM
Illinois University, Urbana, Ship Structure Committee Prog Rpt. SSC-117, July 1959, 7 p, 4 Ref.

Contract NObs-65790

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AD-229845

331907
STUDIES OF THE STRAIN DISTRIBUTION IN WIDE PLATES DURING BRITTLE FRACTURE PROPAGATION
This report summarizes the results of a series of tests made as a part of the study of the propagation of brittle fractures in 6-ft wide steel plates. All plates were tested at an average net applied stress of 19,000 psi, a temperature of about-10 F, and an impact energy of about 1000 ft-lb, which made it possible to superimpose the test data and obtain contours of strain on the surface of the plate for a propagating fracture. Contours of both the maximum principal strain and strain measured with vertically oriented gages for various lengths of crack are presented in this report. A study of all the applicable data from earlier tests made as a part of this program indicates that the strain contour data presented here are also representative of the data from these earlier tests. The studies indicate that for the particular specimen geometry and associated test conditions, the strain field associated with the tip of the advancing fracture remains essentially unchanged after traversing about one-third of the plate width and extends only about 8--10 in. ahead of the crack tip.

Rolfe, ST Lynam, TM Hall, WJ
Illinois University, Urbana, Ship Structure Committee Prog Rpt. SSC-118, Dec. 1959, 64p, 5 Ref.

Contract NObs-65790

ORDER FROM NTIS

AD-231079

331908
A REPLICATION TECHNIQUE FOR THE STUDY OF A BRITTLE FRACTURE OF SHIP PLATE STEEL BY ELECTRON MICROSCOPY
This investigation was undertaken to study the applicability of electron microscopy in determining the relationship of microstructure of ship plate steel to its brittle fracture transition temperature in order to obtain a broader understanding of the phenomena involved in the brittle failure of plating in ship hulls under service conditions. The results for a series of specimens of differing transition temperatures indicate that there is a relationship between the degree of separation of cementite lamellae and the temperature in the transition from predominantly ductile to predominantly brittle fracture: An increase in cementite ordering is correlated to higher transition temperatures.

Haas, EC
New York Naval Shipyard, Ship Structure Committee Final Rpt. SSC-119, Jan. 1960, 14p, 4 Ref.

Contract NObs-72046

ORDER FROM NTIS

AD-231231

331909
WHERE WE STAND IN DESIGN WITH BRITTLE FRACTURE
This review paper presents some of the highlights of the engineering features of brittle fracture together with a summary of some of the current theories, including the recent Cottrell Theory. In an attempt to interpret recent data in the light of the Cottrell theory it is concluded that some modifications in the theory are required to explain recent experimental results. Nevertheless, the dislocation picture of brittle fracture has been very helpful in providing a theoretical framework for the fracture mechanisms, and it is expected that these concepts will be continually developed with more theoretical and experimental work.

Averbach, BL
Massachusetts Institute of Technology, Ship Structure Committee SSC-120, Feb. 1960, 19p, 18 Ref.

Contract NObs-72046

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AD-233572

331910
BEHAVIOR OF RIVETED AND WELDED CRACK ARRESTORS
This report describes the laboratory work undertaken 1) to investigate the feasibility of developing a welded crack arrestor and 2) to observe the behavior of various crack arresting devices. The study was accomplished by propagating a brittle crack, initiated by driving a wedge into a notch at the edge of the specimen, into 2-ft and 6-ft wide steel plates containing either (a) welded inserts of T-1 steel (b) riveted doubler plates or (c) welded inserts of ABS Class C normalized steel, which were located at various distances from the edge of the plate. Most of the tests were conducted at nominal stresses between 20 and 30 ksi and at temperatures between-25 and 40 F. Some of the specimens were instrumented with strain gages to provide information on crack speed and strain pattern.

Mosborg, RJ
Illinois University, Urbana, Ship Structure Committee Final Rpt. SSC-122, Aug. 1960, 114p, 22 Ref.

Contract NObs-65789

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AD-242415

331911
AN INTERPRETATION OF LOWER YIELD POINT PLASTIC FLOW IN THE DYNAMIC TESTING OF MILD STEEL
Evaluation of the role of rapid plastic flow in the fracture process necessitates some measure of elastic and plastic strength which will be suitable for high

strain rates. For a limit to the static elastic strength of mild steel, the lower yield stress is a generally accepted criterion. Its use for the dynamic test, although common in the literature, is more difficult to justify because here neither the lower yield strain along the specimen, nor the lower yield stress, are even approximately constant. The variability of both is a consequence of the fact that in the high strain rate test, a "steady state" form of the Luders strain front is not obtained, nor is it then contained within the length of the specimen. For this paper, strain distribution is measured after stopping a dynamic machine during the lower yield. From head displacement and load records obtained during the test and also from plastic flow rate sensitivity measured in other high-speed tests on the same material, the strain distribution is predicted. The predicted strain distribution behind the Luders band front is found in good agreement with that measured. When the velocity of the band front is corrected for its diminution owing to continued flow behind the front it is related to driving stress with a sensitivity corresponding to that for the upper yield point--or the delayed yield.

Krafft, JM
Naval Research Laboratory, Ship Structure Committee Prog Rpt. SSC-123, June 1961, 19p, 6 Ref.

Contract NObs-72046

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AD-260775

331912
A LONG-RANGE RESEARCH PROGRAM IN SHIP STRUCTURAL DESIGN
This report presents the results of the study, and is concerned specifically with research objectives and approaches aimed at the ultimate improvement in the design of ship hulls of conventional form. It presents a suggested long-range research program based on a critical review of past and current research, calling attention to problem areas where significant advances can be made by further research. The report is in no sense intended as a working design manual, nor does it cover the complete range of ship structural problems.

Borg, SF Korvin-Kroukovsky, BV Lewis, EV Zubaly, RB Becker, H Gerard, G Neumann, G Pierson, WJ, Jr Tick, L
Stevens Institute of Technology, New York University, New York, Ship Structure Committee Final Rpt. SSC-124, Nov. 1959, 221p, Refs.

Contract NObs-72285

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AD-229826

331913
SOME OBSERVATIONS ON THE BRITTLE FRACTURE PROBLEM
The problem of brittle fracture in structural steel has been vigorously attacked by powerful research efforts in many countries, but remains in some respects intractable. The main difficulty seems to lie in defining the problem itself, and in isolating the essential features. The investigations have been characterised by conflicts of ideas on these essentials, and on their interpretation, possibly because the problem has brought together into one forum, as it were, several branches of scientific and technical endeavour which in the past have functioned, to a large extent, independently. This has led to misunderstandings due to differences in terminology and other difficulties due to conflicts of interest. In such circumstances it is often desirable to re-examine fundamentals, and the present notes are an attempt to do this. Such re-examinations often entail the repetition of "obvious" facts, and while this may appear tedious, it is essential to the process. The report reviews kinds and modes of fracture, initiation of unstable fracturing, selection of tests and empirical measures

Boyd, GM
Lloyd's Register of Shipping, Ship Structure Committee SSC-125, July 1959, 20p, 16 Ref

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AD-225028

331914
INFLUENCE OF HOT-ROLLING CONDITIONS ON BRITTLE FRACTURE IN STEEL PLATE
Steel plates processed according to a conventional and controlled (low finishing temperature) rolling practice were studied to establish reasons for a superior notch toughness in the controlled-rolled product. The lower transition temperature (Charpy V-notch 15 ft-lb) in plates investigated is derived largely from a smaller ferrite grain size. Experimental evidence was also obtained to indicate that a part of the improvement results from a microfissuring in the plane of the plate at the notch root, with the effect that stress triaxiality is relieved and transition temperature depressed. The origin of the flaws responsible for the fissures was not determined with certainty, but there was good indication that they were simply inclusions in a fiber structure too fine in scale for observation with normal metallographic techniques. The criteria presented for microfissuring were (1) a flaw structure dispersed on a scale no greater than the size of the plastic volume from which the brittle crack originated; (2) a ratio of the critical fracture stress in thickness (Z) to rolling (R) direction no greater than about 1.2. The necessary fracturing anisotropy was favored by more intense fibering (lower sigma sub Z) and finer grain size (higher sigma sub R). The criteria were most nearly satisfied by controlled-rolled plate. Correlations between sigma sub Z and visible inclusion content showed the decrease in sigma sub Z to be paralleled by more elongated inclusions, as if visible changes are indicative of changes in the fine-scale fiber structure.

Kazinczy, F de Backofen, WA
Oxelosunds Jarnverksaktiebolag, Massachusetts Institute of Technology, Ship Structure Committee Prog Rpt. SSC-126, Nov. 1960, 26p, 28 Ref

Contract NObs-72386

ORDER FROM NTIS

AD-247562

331915
INFLUENCE OF SPEED OF DEFORMATION ON STRENGTH PROPERTIES IN THE POST LOWER YIELD STRESS-STRAIN CURVE OF MILD STEEL
The essence of the correlation procedure attempted here is to associate the average strain-rate sensitivity in plastic flow with the growth speed of the individual plastic zone. Flow is considered to be accomplished by a continuing series of yield initiations in the elastic stress field of such a zone. The non-linear relationship between upper yield stress and stress rate suggests that rate sensitivity will increase directly with zone velocity or inversely with the density of operative zones. Zone density is thought to vary as a function of both strain and strain rate. The influence of the speed of lower yield strain on the distribution of operative slip bands accounts for observed deviations from an equation of state.

Krafft, JM Sullivan, AM
Naval Research Laboratory, Ship Structure Committee Prog Rpt. SSC-127, Dec. 1960, 19p, 11 Ref

Contract NObs-72046

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AD-24[illegible]56

331916
INFLUENCE OF STEEL-MAKING VARIABLES ON NOTCH TOUGHNESS
The relative importance of the process variables seems to be dependent on the test criterion chosen: one variable, for example, would mainly improve fracture appearance, whereas another would mainly affect impact energy. This divergence of effect between process variables would explain the lack of correlation between different test-criteria in comparing plates that have been processed in different ways. For plates having intermediate quality with regard to notch toughness, this point is especially important, since in obtaining this quality usually only one or two of the known process factors are controlled in order to obtain the required properties. In other words, intermediate quality plates may be made in different ways: which way should be chosen by the steelmaker? The answer to this question depends to a large extent on the choice of test criterion. This choice, however, is still different for different users and classification societies, because apparently insufficient common knowledge exists about the correlation between test criteria and service behavior. Further investigation in this field would seem to be very

necessary, especially since the best way to classify steels should be based, in the author's opinion, on requirements that can be measured on the finished product. Specification of manufacturing process by the user should be avoided because this may lead to uneconomic production and may not always be sufficiently adequate. Examples supporting this view are given. The following process variables are discussed:-chemical analysis (especially manganese and carbon content); plate thickness; finish-rolling temperature (controlled rolling practice); deoxidation (semi-killed versus AL killed; normalizing and cross rolling.)

van der Veen, JH
Royal Netherlands Blast Furnaces and Steelworks, Ship Structure Committee SSC-128, June 1960, 33p

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AD-239049

331917
A NUMERICAL SOLUTION FOR THE TRANSIENT STRAIN DISTRIBUTION IN A RECTANGULAR PLATE WITH A PROPAGATING CRACK

A physical lattice model that approximates a continuous material by reducing it to a series of rigid bars and deformable connections is used in this report to investigate the transient-strain redistribution associated with a crack propagating through a rectangular plate. Equations are developed for equilibrium of the lattice model in terms of displacements using plane-stress conditions. A complete set of equations is given to cover all cases of boundary conditions that ordinarily would be encountered in applications of this lattice model. Results of several examples of statically loaded plates analyzed with the lattice model show excellent agreement when compared with an energy method solution. The differential equations expressing the dynamic behavior of the lattice model are developed, and numerical solution of these equations is discussed. Examples are given of application of these equations to a steady-state condition and the calculation of natural frequencies of lattice models. Several examples of the transient-strain redistribution associated with a crack propagating through a plate in finite jumps are presented. Two methods of numerical integration that are suitable for transient solutions of the differential equations are described and applied to the same problem with resulting comparable satisfactory solutions. An immense amount of calculation is involved in solving transient strain-wave propagation problems with the lattice model, and a high speed digital computer is virtually a necessity for numerical solution of problems of any complexity by this method.

Gaus, MP
Illinois University, Urbana, Ship Structure Committee Prog Rpt. SSC-129, Sept. 1961, 78p, 25 Ref.

Contract NObs-65790

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AD-263845

331918
STUDIES OF BRITTLE-FRACTURE PROPAGATION IN SIX-FOOT-WIDE STEEL PLATES WITH A RESIDUAL STRAIN FIELD

This investigation was undertaken to study the propagation of brittle fracture in six-foot-wide steel plates containing a residual strain field with primary emphasis placed on a determination of the fracture speeds and strains associated with a moving crack. Five plates were prepared and tested in which the residual strain field was produced by welding tapered slots cut in the edges of the specimen. The test results clearly showed that the high residual tensile strain at the initiation edge aided the fracture initiation. For specimens with no external applied load, the fractures arrested before completely crossing the specimens; for specimens with external applied loads, even though low in magnitude, the fractures propagated completely across the plates. The recorded fracture speeds were much lower than any previously noted in tests of six-foot-wide plates, ranging from about 4000 fps near the initiation edge to as low as 50 fps in the compressive strain region. The strain response as measured by gages located at various points across the plate showed that the magnitude of peak strain and the size of the strain field associated with the moving crack tip diminished as the fracture propagated through the compressive strain field at reduced speeds.

Barton, FW Hall, WJ
Illinois University, Urbana, Ship Structure Committee Prog Rpt. SSC-130, Apr. 1961, 49p, 6 Ref.

Contract NObs-65790

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AD-255091

331919
BRITTLE-FRACTURE PROPAGATION IN WIDE STEEL PLATES

The experimental phases of the program involved tests of 3/4-in.-thick structural-steel plate specimens, either 2 ft or 6 ft in width. In most cases the plate specimens were stressed uniaxially to about 19,000 psi, cooled to about 0 deg F, and a fracture was started with the notch-wedge-impact method of fracture initiation. Measurements of the strain distribution on the surface of the plate and the crack speed were made as the fracture traversed the plate. Recorded strains generally remained elastic even though the peak magnitudes, in some cases, exceeded 5000 microin./in. The majority of the recorded fracture speeds ranged from 2000 to 4000 fps. For the particular specimen geometry used and associated test conditions, the strain field surrounding the tip of an advancing fracture appears to remain essentially unchanged after traversing about one-third the width of a 6-ft-wide plate. Exploratory studies were also made of the propagation of brittle fractures in prestressed plates. Measured fracture speeds ranged from about 4000 fps in the region of high tensile strain near the initiation edge to as low as 50 fps in the compressive strain region. The intensity of strain in the field associated with the tip of the moving crack diminished as the speed of the fracture decreased. The visual appearance of the future surface was unusually smooth when the crack had run at low velocity, with no evidence of the familiar herringbone pattern. The results indicate clearly that a residual strain field can have a marked effect on the ease of initiation and propagation of a brittle fracture. Analytical studies of plate response were undertaken by representing the plate as a series of initially perpendicular, rigid bars connected at their points of intersection by a deformable node and interconnected at their midpoints by a shear element. Although the grid used was rather coarse, studies with this plate analog indicate that the lattice representation is a promising method of studying plate response during fracture propagation.

Hall, WJ Rolfe, ST Barton, FW Newmark, NM
Illinois University, Urbana, Ship Structure Committee Final Rpt. SSC-131, Oct. 1961, 30p

Contract NObs-65790

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AD-264524

331920
THE FEASIBILITY OF X-RAY INSPECTION OF WELDS USING BACK SCATTERED RADIATION

Theoretical and experimental work was conducted to develop a radiographic flaw detection technique using source and film located on the same side of the plate. In view of a serious limitation on the depth at which discontinuities in steel can be detected (0.20 in.) and long exposure time (20 min. at 250 kv), the method is considered to be unsatisfactory as a critical inspection tool.

Criscuolo, EL Dyer, CH Case, DP
Naval Ordnance Laboratory, Ship Structure Committee Final Rpt. SSC-132, July 1961, 26p, 6 Ref.

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AD-263030

331921
SIZE EFFECT IN BRITTLE FRACTURE OF NOTCHED STEEL PLATES IN TENSION

Direct experimental evidence is presented here to support the hypothesis that A Griffith-type theory is not the critical condition for the initiation of brittle fracture in steel plates. The data indicate almost complete size independence for notched, compressively prestrained, Project E steel specimens of 6-2/3 in., 10 in., and 20 in. widths, which had geometrically similar dimensions in the plane of the plate but were of the same thickness.

Ludley, JH Drucker, DC
Brown University, Ship Structure Committee Prog Rpt. SSC-135, Nov. 1961, 9p, 9 Ref.

Contract NObs-78440

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AD-266451

331922

ON VARIOUS PROBLEMS OF IMMEDIATE INTEREST TO A SHIP CLASSIFICATION MAN

The report reviews the following topics: The Load Line Convention formula for the midship section modulus; A survey of recent cracks in shell and deck; Buckling of deck; T2-tankers; Corrugated bulkheads; Absence of riveted crack arrestors; Broken Scandinavian tankers; Why tankers must be stronger than dry cargo ships; Intersecting girders; Transverse frames and Classification societies.

Vedeler, G
Norske Veritas, Ship Structure Committee SSC-136, Aug. 1961, 19p

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AD-262948

331923

A NAVAL ARCHITECT'S REFLECTIONS ON SOME RESEARCH PROBLEMS WITH SHIP STEEL

The contents of this report is a paper given by the author and reviews generally the importance of fatigue in ships, high yield point and cold working, discussion of details of impact tests, crack propagation and the importance of defining state of stress for temperature dependent properties of steel.

Vedeler, G
Norske Veritas, Ship Structure Committee SSC-140, Aug. 1961, 16p

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AD-262947

331924

MILL SAMPLING TECHNIQUES FOR QUALITY DETERMINATION OF SHIP STEEL PLATE

In order to evaluate the variation in notch toughness of currently produced ship plate steel, studies were made of 105 plates submitted by five producers. The plates were selected to give statistical information regarding the variation in composition, mechanical properties and microstructure that might be expected within heats, within ingots, and with position in the plate, and complete information regarding the processing of the plates was obtained from the producers. The notch toughness was evaluated primarily by the Charpy V-notch impact test, although two cooperating laboratories tested many of the plates with the drop weight and van der Veen slow bend tests. The results showed somewhat different patterns for the fully killed and semikilled grades, and sampling plans for each grade are suggested. Because of the marked uniformity of the mill practices of the producers, it was not possible to assess the separate effects of processing variables on notch toughness.

Staugaitis, CL
National Bureau of Standards, Ship Structure Committee Final Rpt. SSC-141, Feb. 1962, 47p, 14 Ref.

Contract NObs-84321

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AD-273767

331925

INVESTIGATION OF THE NOTCH-TOUGHNESS PROPERTIES OF ABS SHIP PLATE STEELS

The main objective was to determine the extent to which post World War II steels have been improved, based principally on a comparison of their Charpy V-notch properties with those established by the National Bureau of Standards for fractured plates from World War II ships. The initial part of the program (prior to 1956) covered plate procurred to the requirements of the 1948 ABS Rules and included 37 samples of Class A, 81 of Class B and 14 of Class C. In view of the 1956 changes in the ABS Rules, the sampling program was extended to cover primarily the new Class B type but some additional samples of Class C were included to supplement the relatively small number received in the previous sampling. The extended program included 76 samples of Class B and 12 of Class C. The results of the survey indicate that since the 1956 revision of the ABS Rules for Ship Steel, the range and average transition temperatures (15 ft-lb Charpy V) for the new material have been found to be-40 to 29 F and 2 F, respectively, for ABS Class B plates, and-46 to 13 F and-13 F, respectively, for ABS Class C plates, as compared with an average of 90 F for World War II fracture-source plates and 68 F for fracture-through plates.

Gabriel, JJ Imbembo, EA
New York Naval Shipyard, Ship Structure Committee Final Rpt. SSC-142, Oct. 1962, 35p, 12 Ref.

Contract NObs-84321

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AD-292700

331926

CRACK PROPAGATION IN LOW-CYCLE FATIGUE OF MILD STEEL

The investigation reported is concerned with crack propagation in low-cycle fatigue of mild-steel plate specimens and has indicated that during crack propagation the type of loading cycle will affect markedly the fatigue behavior. Several types of reversed loading cycles have been included in the investigation, namely constant load, reduced loads and constant stress. In the constant-load tests the stress increases throughout the test as the crack propagates, and the rate of crack propagation continuously increases. If the load range is reduced throughout a test (reduced-load test) so as to produce constant net-section stresses, the rate of crack growth will decrease throughout the test. In the constant-stress tests the stress range was maintained constant during the test. In this latter use, the rate of fatigue crack propagation remained constant after a short initial period. Constant-stress tests were conducted at stress levels ranging from plus or minus 27 ksi to plus or minus 36 ksi, on 3/4-in. thick specimens with widths of 5 in. and 7 in., at test temperatures of 78 F and-40 F and for both unaged and aged specimens. It was found that the fatigue crack propagation behavior during a constant-stress test may be divided into an initial, linear, and final stage. A hypothesis relating the rate of crack growth and the stress has been developed to describe the behavior during the various stages of propagation.

Rolfe, ST Munse, WH
Illinois University, Urbana, Ship Structure Committee Prog Rpt. SSC-143, May 1963, 50p, 42 Ref.

Contract NObs-77008

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AD-410458

331927

MECHANICAL PROPERTIES OF HIGH-MANGANESE SEMIKILLED STEEL PLATE

Test results obtained on seven production heats of semikilled steel containing 0.20% maximum carbon and 1.00 to 1.35% manganese indicate that as-rolled plates of this composition in thicknesses over 1 to 1-1/2 in. would meet the American Bureau of Shipping tensile requirements but might not have sufficient notch toughness to be considered a suitable substitute for as-rolled ABS Class C steel in thicknesses over 1 in. The results of V-notch Charpy and drop-weight tests were not in complete agreement, and drop-weight transition temperatures obtained with full-plate-thickness specimens were appreciably higher than those obtained with specimens of reduced thickness. The most favorable interpretation of notch-toughness behavior was obtained using drop-weight tests with 1-in.-thick specimens, and, on this basis, the experimental steel in thicknesses over 1 to 1-1/2 in., inclusive, was about as suitable as ABS Class B steel in its maximum thickness of 1 in. It is believed that further testing is needed to determine the best test and testing techniques for evaluating the service performance of plates over 1 in. thick. It does appear, however, that this experimental steel in the normalized condition would be sufficiently notch tough to allow its substitution for either as-rolled or normalized Class C steel, if warranted by economic and other considerations.

Vanderbeck, RW
United States Steel Corporation, Ship Structure Committee Final Rpt. SSC-144, Jan. 1963, 38p, 18 Ref.

Contract NObs-84321

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AD-400278

331928

THE EFFECT OF METALLURGICAL VARIABLES IN SHIP-PLATE STEELS ON THE TRANSITION TEMPERTURES IN THE DROP-WEIGHT AND CHARPY V-NOTCH TESTS

Twenty-nine heats were produced and processed in the laboratory in order to study the effects of composition and ferrite grain size on drop-weight transition temperatures. To provide an internal check and to permit comparisons with other investigations, parallel studies were made on V-Notch Charpy specimens. The experimental steels covered the following ranges in composition: 0.10/0.32% carbon, 0.30/1.31% manganese, 0.02/0.43% silicon, and nil/0.136% acid soluble aluminum. These ranges were intentionally wider than the limits permitted for ship plate. Although most of the data were obtained on hot-rolled samples, some plates were heat-treated in order to cover a wider range in ferrite grain size. The experimental data were used for a multiple correlation analysis conducted with the aid of an electronic computer. The study showed that carbon raises and manganese, silicon, aluminum and finer ferrite grain sizes lower both drop-weight and Charpy transition temperatures. Quantitatively, variations in composition and grain size have a more marked effect on V Charpy transition temperatures than on the drop-weight transition temperature. Useful correlations were found between transition temperatures in drop-weight tests and those defined by seven different criteria for Charpy tests. Evidence was accumulated that conditions ordinarily used for drop-weight tests are more severe for 1-1/4-in. thick plate than for 5/8-to 1-in. thick plate.

Boulger, FW Hansen, WR
Battelle Memorial Institute, Ship Structure Committee SSC-145, Dec. 1962, 74p, 17 Ref.

Contract NObs-84321

ORDER FROM: NTIS

AD-294827

331929

A STUDY OF BRITTLE FRACTURE INITIATION IN MILD STEEL

The purpose of this investigation was to study the conditions of brittle-fracture initiation in low-carbon steel. An elastic-plastic stress analysis was developed from which the state of stress along the minimum section of a notched specimen could be determined as a function of the average applied stress and the yield stress. A series of tests on plate-type specimens, with the same notch configuration as that used in the stress analysis, provided experimental values of average fracture stress under various test conditions. Application of the elastic-plastic stress analysis to the experimental results provided a theoretical prediction of the state of stress at the instant and location of fracture initiation and also an indication of the position of the elastic-plastic boundary at fracture. It was found that the stress condition necessary for brittle fracture initiation, in the mild-steel specimens studied, was achieved when the maximum tensile stress reached a critical value of approximately 246,000 psi. For a ratio of average applied stress to yield stress above a certain value, the maximum tensile stress cannot attain the necessary stress value for the initiation of a brittle fracture as defined herein, and the resulting fracture will be ductile in nature, preceded by gross plastic deformation. Results from this investigation were compared with existing information related to fracture initiation to provide a basis for evaluating both the analytical technique employed and the final results obtained.

Barton, FW Hall, WJ
Illinois University, Urbana, Ship Structure Committee Tech Rpt. SSC-147, July 1963, 30p, 19 Ref.

Contract NObs-65790

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AD-419617

331930

BRITTLE FRACTURE PROPAGATION STUDIES

This investigation was undertaken to study low-velocity brittle fracture in wide steel plates. The detailed results of two tests of 6-ft-wide prestressed steel plates are presented along with pertinent observations from tests of similar specimens conducted as one of the last phases of Project SR-137. Also, results of nineteen tests of 2-ft-wide centrally notched plates, a majority of which had a longitudinal butt weld are presented. In 6-ft-wide prestressed plates, the residual stress field (longitudinal tensile stresses at the edges of the plate balanced by compressive stresses throughout the central portion) made initiation possible with no external applied stress, and had a significant effect on the fracture propagation. Fracture speeds were high (4000-6000 fps) near the edges of the plates and decreased rapidly to as low as 165 fps as the fracture propagated into the region of compressive stresses. In the low-speed regions the magnitude and extent of the dynamic strain field associated with the crack tip was considerably less than had been recorded in earlier tests of high-speed fractures in plain plates. For the 2-ft-wide centrally notched and welded plates in which the fractures were initiated statically, fracture speeds as high as 5000 fps were recorded in the zone of high residual tensile stresses near the weld; the speed apparently stabilized at about 1800 fps after the fractures had propagated out of the high tensile stress field. The dynamic strain field associated with the intermediate-speed fractures (1800 fps) were roughly commensurate with that which would be expected for this fracture-velocity level. The fracture initiation observations indicated that the tensile residual stress alone was not sufficient to insure low-applied-stress fracture initiation; also, metallurgical effects associated with high-heat input during welding are not necessary in all cases for low-stress initiation. Indications are that strain cycling of the material in the notch region arising from welding may play an important role in the initiation of brittle fractures.

Videon, FF Barton, FW Hall, WJ
Illinois University, Urbana, Ship Structure Committee Prog Rpt. SSC-148, Aug. 1963, 35p, 14 Ref.

Contract NObs-65790

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AD-424985

331931

SUMMARY OF SOME STUDIES OF BRITTLE-FRACTURE PROPAGATION

The most significant observations arising from experimental studies of brittle-fracture propagation in wide steel plates conducted as a part of SSC Projects SR-137 (Fracture Mechanics) and SR-155 (Low-Velocity Fracture) are summarized. Six-foot-wide plain plate specimens tested at an average applied stress of about 20 ksi, a temperature of 0 deg F, and with the notch-wedge-impact method of initiation, in order to study fracture propagation under relatively steady state conditions produced fracture speeds in the range of 2000 to 4000 fps. Six-foot-wide prestressed steel plates with a region of high tensile residual strain at each edge, and a region of residual compression in the central portion, tested at zero or 3 ksi average applied stress, at 0 deg F, and with impact initiation, produced fracture speeds of 6000 fps in the tensile zone near the initiation source, and speeds as low as 50 fps in the central portions of the plate. Two-foot-wide centrally notched and welded specimens fabricated in different ways and tested at an average applied stress of about 10 ksi and a temperature of-40 F, produced speeds within 1-1/2 inches of the initiation source and in a region of high residual tensile stress as high as 5000 fps whereas speeds throughout the remainder of the specimen, which initially possessed a low compressive residual stress, were on the order of 1800 fps. Fracture texture, the effects of thermal strain cycling, notch geometry, and surface strain field associated with the advancing fracture at both high and low velocities have been observed and reported.

Hall, WJ Barton, FW
Illinois University, Urbana, Ship Structure Committee Final Rpt. SSC-149, Sept. 1963, 13p

Contract NObs-65790

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AD-424986

331932

PRELIMINARY ANALYSIS OF BENDING-MOMENT DATA FROM SHIPS AT SEA

Data playback, manual reduction and analysis techniques, and the automatic system to be used for future analysis are presented. Examples are given

of some forms of presentation of long-term trends. Useful data have been obtained on over 85% of voyages representing three ship-years of operation of a C-4 dry cargo vessel on North Atlantic trade routes. Two complete voyages have been analyzed using manual techniques and the results of this analysis are presented. The maximum observed peak-to-peak variation of wave-induced stress was 8300 psi which occurred during a Beaufort 11-12 Sea. A prediction based on the limited amount of long-term data available from the two analyzed voyages yielded an extreme value of 10,290 psi for a year of operation of this ship type on North Atlantic route. Stress variations on the order of 9,000 psi have been observed during the dry docking of the two instrumented ships.

Fritch, DJ Bailey, FC Wise, NS
Lessells and Associates, Incorporated, Ship Structure Committee Prog Rpt. SSC-153, Dec. 1963, 34p, 6 Ref.

Contract NObs-77139

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AD-436877

331933
COLUMBIUM AS A MICRO-ALLOYING ELEMENT IN STEELS AND ITS EFFECT ON WELDING TECHNOLOGY
The report covers weldability as a metallurgical concept and a complex problem in steel metallurgy. Micro-alloy steels are defined and the general influence of Columbium as a micro-alloying element is discussed as well as the metallurgical variables. The basic properties of Columbian steels are presented versus processing variables such as: Properties versus composition, rolling conditions and heat treatment. The special properties of columbium steels are reviewed versus welding technology and the application of the steels to welding fabrication.

Noren, TM
Oxelosunds Jarnverk, Ship Structure Committee SSC-154, Aug. 1963, 49p, 25 Ref.

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AD-424983

331934
AN INVESTIGATION OF MIDSHIP BENDING MOMENTS EXPERIENCED IN EXTREME REGULAR WAVES BY MODELS OF THE MARINER TYPE SHIP AND THREE VARIANTS
This report summarizes experimental research to investigate the possibility of a physical upper limit on midship bending moments in the Mariner-type ship being reached in regular waves of height significantly less than the theoretical upper limit of stability for progressive waves (h/lambda = 1/7). The experiments included variation of distribution of loading and of freeboard as model parameters. Each variation was tested at various speeds in regular head and following waves of several different lengths and of a wide range of heights. No significant upper limit of bending moment was found. However, the study establishes more firmly the grossly linear dependence of midship bending moment on wave height, even for extreme wave heights which may be encountered in service. These findings strengthened the case for determining design wave bending moments on the basis of statistical analyses of ocean waves and/or resulting bending moments.

Dalzell, JF
Stevens Institute of Technology, Ship Structure Committee Prog Rpt. SSC-155, Jan. 1964, 56p, 9 Ref.

Contract NObs-78211

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AD-432278

331935
AN INVESTIGATION OF MIDSHIP BENDING MOMENTS EXPERIENCED IN EXTREME REGULAR WAVES BY MODELS OF A TANKER AND A DESTROYER
This report summarizes experimental research to investigate the possibility of a physical upper limit on midship bending moments in tanker and destroyer type ships being reached in regular waves of height significantly less than the theoretical upper limit of stability for progressive waves (h/lambda-1/7). Each model was tested at various speeds in regular head and following towing tank waves of several different lengths and of a wide range of heights. The results were compared with those obtained previously for a modern cargo vessel. No significant upper limit of bending moment was found. However, the study establishes more firmly the grossly linear dependence of midship bending moment on wave height, even for extreme wave heights which may be encountered in service. These findings strengthened the case for determining design wave bending moments on the basis of statistical analyses of ocean waves and/or resulting bending moments.

Dalzell, JF
Stevens Institute of Technology, Ship Structure Committee Prog Rpt. SSC-156, Feb. 1964, 42p, 11 Ref.

Contract NObs-78211

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AD-432182

331936
LOW-STRESS BRITTLE FRACTURE IN MILD STEEL
The report begins with a delineation of the problem followed by a description of the tests and measurements derived to determine the strain distribution during loading in a precracked specimen. All tests were done at room temperature above the temperature of initiation of a brittle crack. The behavior of cracked plates, embrittled steel and welded wide plate is discussed.

Dechaene, R Soete, W Vinckier, A
Ghent University, Ship Structure Committee SSC-158, Aug. 1963, 18p, 12 Ref.

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331937
ACQUISITION AND ANALYSIS OF ACCELERATION DATA
As part of a broad investigation with the objective of developing information on extreme values of load conditions to which cargo might be subjected, seven accelerometers and and unmanned recording system were installed aboard a dry cargo vessel on regular North Atlantic service, and data were obtained over a period of 15 months. The immediate purpose was to establish the basis for prediction of extreme values of acceleration which would be encountered by cargo in the vessel over long periods of time. The data acquisition system operated satisfactorily for slightly less than 14 of 15 round-trip voyages, or an efficiency of approximately 90%. Analysis was based on data accumulated for 30 minutes every four hours representing a total of over 8000 hours of ship operating time of which 6200 hours were in the open ocean. Analysis of wave-induced accelerations using a special purpose probability analyzer resulted in a maximum observed acceleration (bow, vertical) of 1.76 g's peak-to-peak. This value is within 6% of the predicted value for the same circumstances. Slamming or pounding combined with other phenomena resulted in higher frequency accelerations (in the range of 10 cps) in excess of 3.0 g's peak-to-peak. Contrary to expectations, the peak accelerations observed under conditions of "slam" or "pound" were largely the result of hull vibrations of a high mode, and were apparently excited in part by the second order of propeller blade excitation.

Bailey, FC Fritch, DJ Wise, NS
Lessells and Associates, Incorporated, Ship Structure Committee Prog Rpt. SSC-159, Feb. 1964, 65p, 8 Ref.

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AD-430742

331938
GEOMETRIC EFFECTS OF PLATE THICKNESS
The results of the investigation can be summarized as follows: (1) The van der Veen test, the Bagsar test, and the drop-weight test showed general agreement in their response to changes in plate thickness ranging from 3/4 to 3 inches. (2) The dimensional effect of plate thickness, with metallurgical variables held constant, was to raise the transition temperature markedly as the plate thickness was increased from 1/2 to 1-1/2 inches. Above 2 inches, thickness appeared to have much less effect on the transition temperature

observed in these sharply-notched specimens. ABS Class C and "T-1" steels behaved similarly in this respect. (3) In the presence of a severe notch, specimen widths and heights of 2 inches or greater appear adequate to determine the sensitivity of heavy-section steel plate to brittle fracture. (4) The van der Veen specimen is recommended as the testing method for the second phase of the program because of its testing convenience and its suitability for determining transition temperatures by a variety of criteria.

Stout, RD Roper, CR Magee, DA
Lehigh University, Ship Structure Committee Prog Rpt. SSC-160, Feb. 1964, 23p, 12 Ref.

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AD-430686

331939
STUDIES OF SOME BRITTLE FRACTURE CONCEPTS
Linear elastic fracture mechanics is used in evaluation of the fracture toughness disclosed by the arrest of cleavage fractures in notched and welded wide plate specimens. Fracture toughness values also are obtained from strain field measurements in the vicinity of propagating cracks on the verge of arrest in 6-ft-wide plates. The results clearly show the trend towards "toughening" at higher temperatures and the major role residual stress fields can play in driving fractures. An experimental investigation was conducted to investigate the influence of welding on the yield behavior of metal from the thermally affected zone in the vicinity of a weld. The rate-temperature dependent component of the yield stress appears to be the same for base metal and metal from the thermally affected zone, but the yield stress of the thermally affected zone metal shows a substantially increased rate-temperature independent component. A critical stress model for the prediction of brittle cleavage fracture is developed and applied to cleavage initiation, propagation, and arrest. The model approximately accounts for inelastic behavior near a flaw by truncating the elastic stress distribution. Effects of rate, temperature, notch acuity, local strain hardening, residual stress, and propagation velocity are considered; the model demonstrates good qualitative representation of the effects of these parameters on the susceptibility to cleavage. Correlations with experimental results show the model is capable of quantitative representation of the effects of rate and temperature on the applied stress required for the initiation of brittle cleavage fracture and the stress required for continued cleavage propagation. The study suggests that low-stress cleavage initiation at service temperatures can be associated with a marked local reduction of critical fractures, stress, that residual stresses can be responsible for the propagation through sound metal of fractures initiated in damaged material, and that the critical fracture stress and fracture mechanics approaches are equivalent when applied to cleavage propagation and arrest.

Wright, RN Hall, WJ Terry, SW Nordell, WJ Erhard, GR
Illinois University, Urbana, Ship Structure Committee Final Rpt. SSC-170, Sept. 1965, 86p, 58 Ref.

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331941
DESIGN AND INSTALLATION OF A SHIP RESPONSE INSTRUMENTATION SYSTEM ABOARD THE CONTAINER VESSEL S.S. BOSTON
Progress during this reporting period consisted of design, procurement, and installation of a ship response instrumentation system aboard the container vessel S.S. BOSTON. Included in this report are the following: a detailed description of the system, consisting of the parameters to be measured; the type and location of the transducers installed; components and functional operation of the data acquisition and recording system; data analysis procedures, and equipment specifications. In addition, a description of the procedure and the results of the first transducer calibration attempt are presented.

Fain, RA Cragin, JQ Schofield, BH
Teledyne Materials Research, Ship Structure Committee Prog Rpt. SSC-211, Dec. 1968, 14p

Contract N00024-68-C-5486

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AD 780090

334343
SUMMARY OF NONDESTRUCTIVE INSPECTION STANDARDS FOR HEAVY SECTION CASTINGS, FORGINGS, AND WELDMENTS
Code bodies, notably ASTM, have produced procedural guides, standard methods, and recommended practices which can be used to assure proper inspection for the various methods of nondestructive testing. These guides and practices in private industry have been reviewed for their applicability to quality control of heavy steel castings, forgings, and weldments. Acceptance criteria are not set forth, and recommendations are not suggested. They do, however, define levels of quality and describe the parameters generally agreed to be of significance which should be a part of the contractural agreement. The user must quantify these parameters according to service requirements and other considerations.

Youshaw, RA
Naval Surface Weapons Center, United States Coast Guard, Ship Structure Committee Final Rpt. SSC-300, 1981, 32p

Contract NAVYZ 70099-6-71375

ORDER FROM: NTIS AD-A099119

334344
PROBABILISTIC STRUCTURAL ANALYSIS OF SHIP HULL LONGITUDINAL STRENGTH
Existing probabilistic structural design methods are reviewed, their applicability to ship hull structural design considered and the most promising probabilistic analysis techniques are identified. The current state of knowledge concerning structural modes of failure and load distribution is considered with respect to its impact on probabilistic structural analyses. The emphasis is on longitudinal strength considerations. Factors influencing strength, in terms of uncertainties in ship strength distribution, are reviewed. Different methods are proposed to obtain coefficients of variation for various types of data on the uncertainties. Sample calculations are performed for a number of ships using an approximate probabilistic method and yielding safety margins for each. This method requires that only the coefficients of variation of the strength and load be known. A computer program is developed to perform this calculation for any ship subjected to any load or mode of failure.

Daidola, JC Basar, NS
Rosenblatt (M) and Son, Incorporated, United States Coast Guard, Ship Structure Committee SSC-301, 1981, 88p, 67 Ref.

Contract DOT-CG-61908-A

ORDER FROM: NTIS AD-A099118

334345
COMPUTER-AIDED PRELIMINARY SHIP STRUCTURAL DESIGN
Undoubtedly, ship structural design and analysis is an area that is receiving some benefits from the rapid advances of computer technology. In this report, an evaluation is made of the current trends in computer-aided structural design systems and their possible impact on the preliminary structural design of ships. The survey and evaluation covers marine software systems as well as non-marine systems such as those used in the aerospace industry and civil engineering structures. The elements of an "ideal" program suitable for the preliminary structural design of ships are identified and used in the evaluation of available software. Suitable programs are then selected for the various typical aspects of ship preliminary structural design. An assessment of the potential technical and economic benefits that might accrue from using a computer-aided design system is made. A recommendation is is also made for the development of a software system with its various components described in detail. An extensive list of existing programs is appended to this report.

Mansour, AE Thayamballi, A
Mansour Engineering Incorporated, United States Coast Guard, Ship Structure Committee Final Rpt. SSC-302, 1981, 126p, 278 Ref

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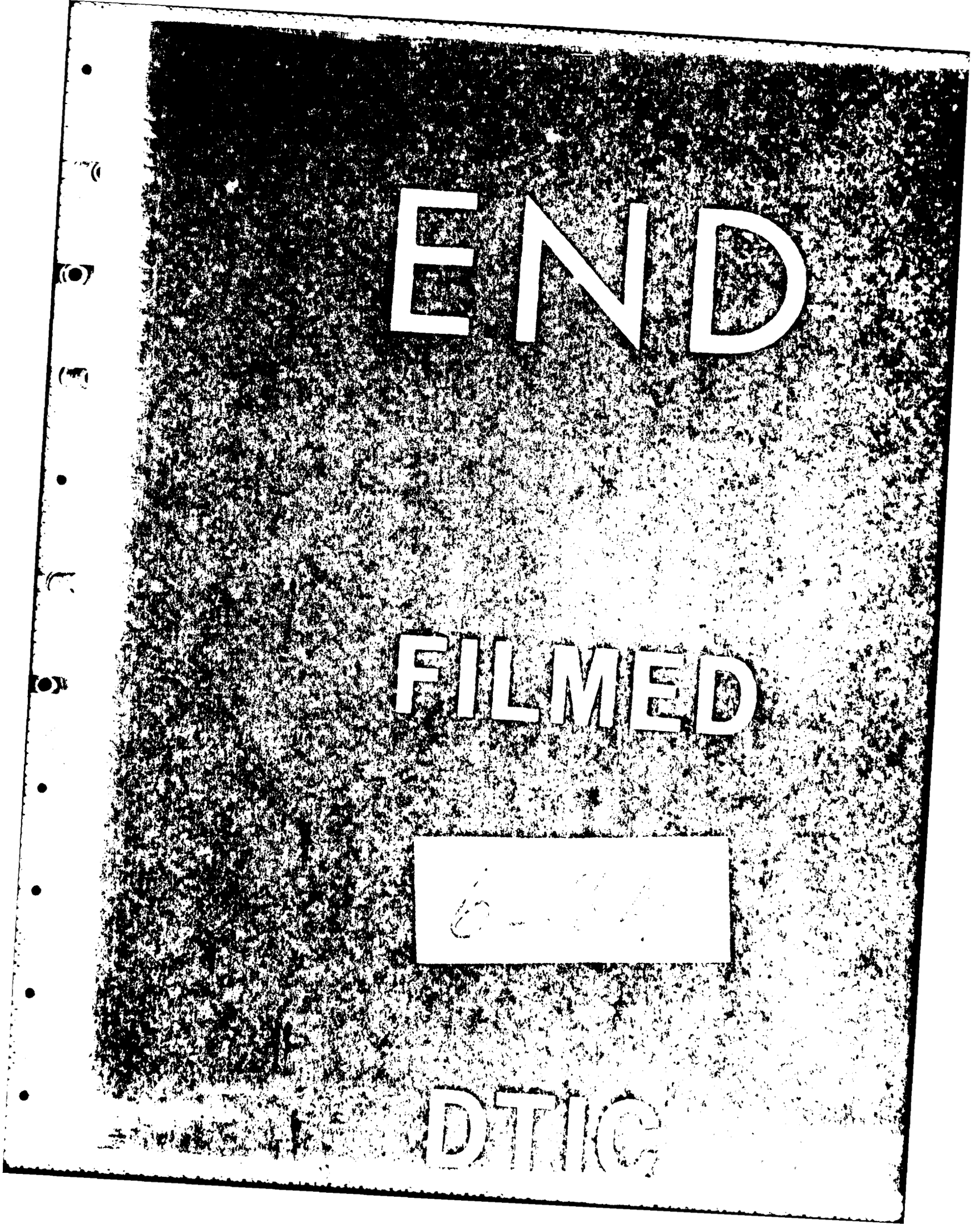
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